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ECONOMIC GEOGRAPHY

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OCTOBER

NORTHERN TRIPOLITANIA: A DRY MEDITERRANEAN COASTAL REGION

A. J. Hornby

THE WASHINGTON APPLE INDUSTRY

Rayburn D. Tousley and Hoyt Lemons

THE GROWTH OF BRISTOL

Henry Rees

IRON IN THE ADIRONDACKS

Sven A. Anderson and Augustus Jones

WATER SUPPLY AND PROGRESS IN THE RED RIVER BASIN

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ECONOMIC GEOGRAPHY

CONTENTS FOR OCTOBER, 1945

NORTHERN TRIPOLITANIA: A DRY MEDITERRANEAN COASTAL REGION 231
A. J. HORNBY

THE WASHINGTON APPLE INDUSTRY. II. ECONOMIC CONSIDERATIONS 252
RAYBURN D. TOUSLEY AND HOYT LEMONS

THE GROWTH OF BRISTOL 269
HENRY REES

IRON IN THE ADIRONDACKS 276
SVEN A. ANDERSON AND AUGUSTUS JONES

WATER SUPPLY AND PROGRESS IN THE RED RIVER BASIN 286
J. R. SCHWENDEMAN

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APPLES

AS Bacon emphasizes in his essay "On Gardens" it was God almighty who made the first garden, and set therein the tree of the fruit of knowledge which Eve and Adam later proved to be the apple. Ever since that time, gardens have been set out and apple trees have been planted, much to the delight of man and woman both, even though apple pies and apple butter and apple sauce have supplanted as sources of temptation the knowledge that the original tree bore.

Wherever man goes that apple trees will grow, there he plants his orchards to yield him the most tempting, and the most satisfying, of all fruits. There are few homesteads throughout the broad expanses of the cool temperate belts, where the white man and his apple thrive best, that are not marked by their little groves of apple trees bearing in season precious, delectable fruit, still as tempting as in Eden.

And in this belt, both north and south of the Equator where conditions of climate and soil and economic development are most favorable to the heaviest yields of that most appetizing fruit, the apple, great commercial orchards have been planted, where all the Eves of the world may find delicious fruit wherewith to tempt their Adams. In America's Northwest, her Ozarks, her Rocky Mountain Forelands, her Great Lakes Littoral, her Ridge and Valley Belt of Pennsylvania and Virginia, her New England, the apple has been planted. In the Argentine oases and Andean piedmonts, in Tasmania, in New Zealand, in South Africa, everywhere he goes the European has planted apples, apples native to his European orchards.

ECONOMIC GEOGRAPHY

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NORTHERN TRIPOLITANIA: A DRY MEDITERRANEAN COASTAL REGION

A. J. W. Hornby

NORTHERN Tripolitania is the most important part of the one-time Italian territory of Libya and has, since the earliest recorded times, a political entity of some importance. On the eastern and western boundaries desert regions extend almost to the Mediterranean shores, separating the region under review from Tunisia on the west and Cyrenaica on the east. It is necessary, from various points of view which will be dealt with, to divide this region into zones of the fertile maritime littoral; of the coastal plain covered almost entirely with its fine sandy soils; of the scarp-lands, rolling hills, and fertile valleys of the Jebel Nefusa, and of the semi-desert, essentially a plateau area, bounded by the Red Desert, Hamada el Hamra, to the south (Figure 1).

The most populous areas are near the Mediterranean, where the fertile lands and main urban areas are traversed by an important highway and a partly-built railway. This route is the African Road of the Aggressors, across which armies of many different nationalities have passed to the conquest of ancient Numidia and Emporia, which included the present region of Tripolitania, to the raids on Egypt of the Pharaohs and later to the successive spoliation or restoration of the great cities which had existed on the littoral of northern Africa for centuries.

As far as records go, the history of this region, covering a period of 3000 years, is of the greatest interest in its connection with that of the Mediterranean as a whole, even down to the present World War, but again for 2000 years before that period, the cities of Numidia were rich and powerful, now almost vanished in the sands, or on the shores of great marshes, once inland seas, and were possessed of considerable culture and literature.

Tripoli is now the only city, transformed during recent years from a dusty, ramshackle Turkish village outside the walls of the ancient town to its present state with good water supplies, sanitation, wide roads, and carefully preserved antiquities. Photographs of this area taken as late as 1911, the year of Italian occupation, are unrecognizable (Figure 2). Tripoli has a fair climate, a rainfall adequate for the water supplies and winter crops, with a port which in normal times can carry on an extensive trade, where some small industries flourish, and which is the religious and cultural center for the Moslem, Italian, and Jewish communities.

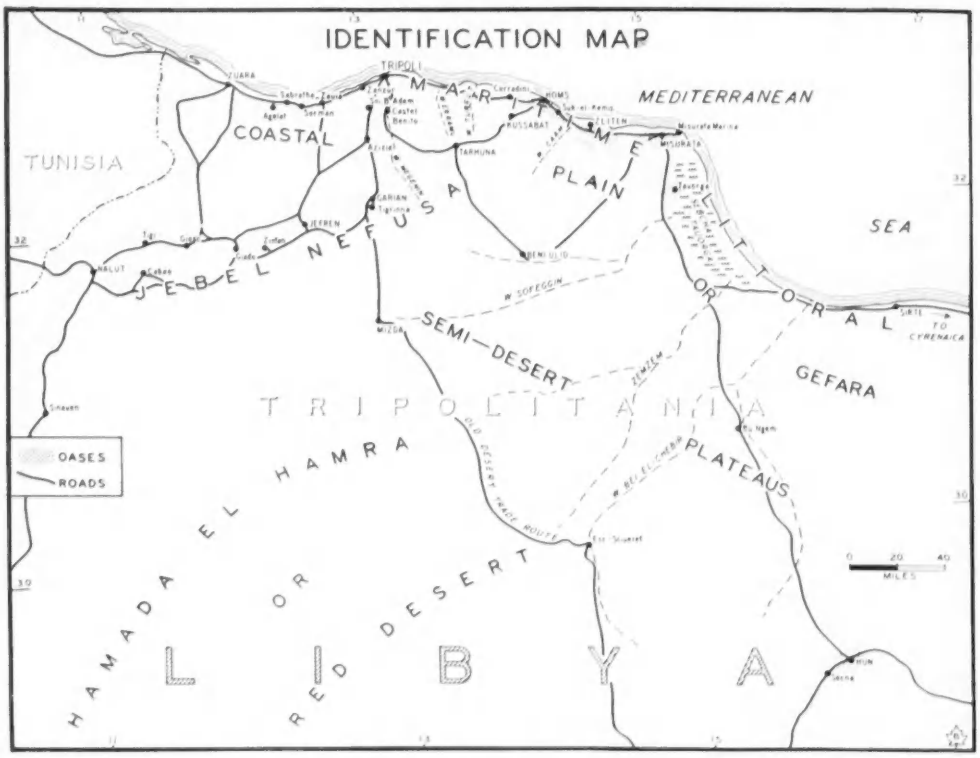

FIGURE 1.—Location Map of Northern Tripolitania.

PHYSIOGRAPHY AND WATER SUPPLY

The four zones of northern Tripolitania mentioned above have generally limestone sub-strata, the escarpments of Lower Cretaceous formation, dipping to the south, sharply dividing the Jebel Nefusa from the coastal plain, and littoral, the former being often referred to as the Gefara. The Jebel itself is almost entirely of limestone of Upper Cretaceous formation, with a few intrusive masses of basalt and other volcanic rocks, particularly near Garian.

The main features of the maritime littoral are the highly cultivated fertile oases. These can be distinguished from the higher and less fertile areas, which intervene between them, stretching generally to the south through the gradually rising Gefara, by the thousands of date palms, the cultivated fields which can almost without exception be irrigated from wells, the universal boundary walls of beaten earth and the flat-topped white houses built of limestone blocks or beaten earth, which, consisting of silty sand, consolidates well when some organic materials are added. The oases are well supplied with water from the winter rains, the run-off from the numerous limestone outcrops and the Jebel scarps, water from which in some areas reaches dimensions liable to do considerable damage (Figure 3). There is also a considerable volume of underground water, accumulated by seepage from the higher land, which, even in the driest seasons, causes the wells to give sufficient supply for many summer crops. Even on the cliffs near Tripoli and near the limestone reefs of the coast, this water is abundant and contains little dissolved matter. There are

exceptions where the water contains much saline and lime compounds, which inhibits or retards growth, as at Misurata, and round some artesian wells, recently sunk in many areas by the Italians (Figure 4).

The less fertile areas of the littoral are the few fine sandy beaches, the rolling sandy grasslands with occasional small shrubs and geophytes and the dunes of fine sand themselves. The latter cover an appreciable area and often rise to many feet with a long sharp edge from which the sand is blown by the frequent land and sea breezes. The bare dune hummocks are in fact always in a state of movement and being a danger to the cultivated areas near by have received some attention from the point of view of fixation by planting indigenous grasses and some exotics proved useful for that purpose, a process of reclamation and reducing wind erosion which should be greatly extended on both governmental and village communal bases.

Another feature of the littoral and the coastal plains are the wadis, which often reach dimensions of giant gullies, cutting through what were once grasslands and farmlands, and with high vertical walls, sometimes reaching 80 feet of reddish sand (Figure 5). Commencing in the Jebel scarp-lands, they receive the torrents of the winter rains and may join in the plains to give very large wadis, some of which called Wadis Lebda, Megenin, Caam, Turgut, Zemzem, and Sofeggin are many miles long and have figured prominently in the past history of Tripolitania, particularly before excessive erosion took its toll, as fertile well watered valleys, provided with many wells and often huge dams for the Roman cities and ports which flourished in those days.

The only stream in the coastal plain with a perennial flow is the Tauorga, with a negroid settlement, surrounded by marshy lands, into which soaks the storm water from the Sofeggin, 250 miles long. In the Jebel Nefusa itself are the small perennially flowing head waters of the Wadi el Angar near Jefren and of the Wadi er Raml near Tarhuna, but in the normal summer period, these streams disappear after a few miles, being lost in the sandy wastes of the plains. There are no other perennial streams although large hot springs exist on the coast, but although attempts were made thoroughly to study and utilize these supplies, much more could now be done.

Turning again to the coastal plains which gradually rise from the littoral, their greatest altitude of 600 feet is attained at the base of the scarps south of the main Tripolitan area, but where the Jebel Nefusa circles this area to the northeast, reaching the littoral near Homs, the altitude decreases and the irregular foothills with deep ravines encroach almost onto the seashore.

The coastal plains to the east of these foothills and continuing in a narrow belt to Sirte surround scattered oases of the pleasant Suk-el-Kemis, near Homs, of Zliten, Misurata, and Tauorga. These eastern coastal zones have a smaller rainfall and are not generally so fertile as those of the west. The agriculture practised by the Moslem small holders is again different in many respects, variations being found in the rotations and in the species and varieties of cereals grown—wheat, sorghum, finger and pearl millet.

The Jebel Nefusa itself is a great range stretching from Nalut round to Homs as has been observed, and is the dominant feature of all northern Tripolitania. Rising to over 2600 feet near Jefren and Garian, peaks of 2000 feet and over are found as far as Tigi to the west; but eastwards there is a general fall to the foothills where the great olive-

growing valleys are found, as at Kussabat (Figure 6). Here in the valleys and ravines as at Corradini and Gasse Daun were built great Roman dams, the ruins of which can still be seen.

The high regions are now denuded of indigenous trees which have good boles of several feet in length, beyond a few Christ's thorn, batum trees, white thorn and camel thorn, tamarisk, and a very rare sumach. There are no areas of close growing shrubs and small trees which can be called by any stretch of the imagination woodland or forest. The same can be said of the coastal plain and littoral zones, unless the close growing tamarisk coppice and small tree growth in the Sofeggin and at Tauorga be excepted. This denudation has had a great influence on the soils of the country, on the configuration and water supply and even slightly on the climate (Figure 7).

Drainage from the rolling hills and fertile valleys of the main high Jebel range is generally to the south, but the storm water becomes tributary to great wadis such as the Sofeggin, running west to east. In the eastern foothill area, the drainage is again to the east.

Cisterns for catching water from the impervious outcrops have been used from time immemorial by the Berber farmers, and the system has been greatly extended in the Tigrinna area by the Azienda Tabacchi Italiani among the share croppers. Some of the wide valleys to the south of the Jebel receiving this storm water are inhabited by farmers who conserve water and soil to grow palms, olives, grain, and other crops. Such is the 20-mile long valley of Beni Ulid, where the rainfall averages only five inches, surrounded by rolling arid country with depressional grasslands and thorn scrubs, particularly much branched Christ's thorn, covered with wind and storm accumulated sand. These arid gravelly wastes through which the valleys cut are the semi-desert, of which the Sofeggin is roughly the southerly boundary, ranging from 1800 to 1500 feet south of the Jebel range and merging into the Red Desert. From the headwaters of the Sofeggin, the limits of the semi-desert proceed in a northwesterly direction.

HISTORY

History records the founding, in the twelfth century before Christ, of the Phoenician trading station of Lepcis, afterwards Leptis Magna of the Romans, where much trade including ivory and slaves was carried over the great southerly routes of the Sahara, then not a desiccated land, but green with shrubs and grass and with the valley oases, separated by easy journeys for ox-carts.

In course of time Lepcis, with the two magnificent cities of Oea (now Tripoli) and Abrotonon (now Sabratha) rivalled Carthage as great trading centers on the coast of North Africa. Herodotus in particular referred in the fifth century B.C. to the state of Tripolitania, especially the well wooded areas round Lepcis, but others such as Pytheas, who lived in the fourth century B.C. and who visited the known western world as far as Britain, have testified to the large fertile areas stretch-

FIGURE 2.—Tripoli has been changed since 1911 from a Turkish village into a modern city. (Courtesy of Dr. Cesare Chiesa.)

ing inland from the sea, the oases, well watered in the depressions and covered with miles of palm stands. Elephant, antelope, and wild beasts roamed the woodlands on the coastal plain, and the mountain plateaus far to the south. Agriculture in the maritime zones had reached a high state of development, dry farming being practised by the Phoenicians.

During the centuries when these Phoenician cities were rich and powerful, there was a considerable population all over the coastal plains and in the Jebel Nefusa, the mountains which ring the main plain.

Rome occupied the coastal areas some time before the fall of Carthage in 146 B.C. and eventually the three cities gave their name to the province. Roman settlement and a chain of Roman military posts penetrated into all parts of the territory. By 125 B.C. the population was so considerable that during a serious locust invasion, several hundred thousand people died from starvation, a figure of 800,000 dead being given for all Numidia, Tripolitania, and Cyrenaica. It may be remarked that locust invasions have occurred at intervals of a few years throughout recorded history and have led to much destruction of crops and food shortage. During the last invasion of 1944, beyond the up-to-date methods of poison bait, the hoppers were dealt with by methods of driving into long pits and on to glowing embers in trenches—methods used by the Romans.

During the heyday of Rome in Tripolitania, there were smiling farms, with very large olive groves, orchards of figs and almonds and fields of golden corn, all over the coastal plain, which must have been much more fertile than at present. Millions of well-planted date palms covered the large oases. Extensive irrigation works were constructed in many gullies and in broad and long depressional grassland which came to be called wadis as erosion cut deep with them. Numerous wells and cisterns existed since the earliest times in the oases. The ruins of Roman farms, of stone oil-presses, and of the three cities themselves tell of the prosperous early times, when the native Berbers were friendly and formed a large farming community. All along the roads of this country as in western Barbary, one could travel under the shades of trees, of indigenous tamarisk, white and camel thorn, batum and palm and hedges of Christ's thorn. As late as 50 A.D. Pliny refers to the extensive woodlands in the valleys of the Gebel. To state, however, that Tripolitania had ever a large surplus of corn for the granaries of Rome is a fallacy. The province was forced to contribute a certain amount, but from all Roman Africa at the best of times, the impost only brought in, on an average, about enough to feed 350,000 people.

Even during this period denudation and soil erosion were beginning to be much in evidence. As Tertullien wrote at the beginning of the third century when the Romans introduced camels, better to travel on the increasing sandy wastes in the southern parts: "De riants domains ont effacé les désert le plus fameux, les champs cultivés ont dompts les forêts, les troupeaux ont mis en fuite les bêtes feroces."

About 400 A.D. the Berbers rose and doubtless aided by their numerous camels took the coastal cities, the latter again being occupied by the Vandals about 50 years later. As far as is known, there was little change in the agriculture of the land, in the irrigation works among the olive groves and date palms, the small farmers still carrying their produce to the cities. The Emperor Justinian's general, Berzelius, re-

took Tripolitania for the Byzantine Empire in 531 A.D., under which it remained for 112 years but during this period there was nothing like the previous settlement of Roman farmers which took place in the years from 146 B.C. to 400 A.D.

The Arab invasion commenced in 467 A.D. and soon afterwards Tripoli, then a city protected by tremendous walls, parts of which still stand, was taken by a stratagem without loss. Although the Arabs and particularly the terrible Beni Hillah tribes are blamed for destruction of fair farms, of the old concrete irrigation works, great ruins of which are still standing, oases in the maritime littoral produced an abundance of grain, fruit, vegetables, and dates in particular. Stock was plentiful in the coastal plains, camels, sheep, donkeys, horses, and the ubiquitous destructive goat attaining great numbers.

The Berbers of the Gebel were kept in check by a standing army of Moslem knights at Lebda (ancient Lepcis) which was necessary as 60,000 warriors from the hills could raid the coastal settlements.

Farmers, largely of Berber stock as they are to this day, waxed fat on the plains. The Islamic civilization, with interludes of Turkish coastal overlord-

FIGURE 3.—Small oasis of Bu Gheilan, Tripoli Province with date palms and small planting of Capsicum (red pepper), tomatoes, lucerne; olives in background. (Courtesy of Dr. Cesare Chiesa.)

and of the magnificent olive groves, the real story is otherwise. The records of el-Bekri, who wrote in 1068, after the Beni Hillah had passed by are of great interest in showing the state of the country at this time. Tripoli had a large population with a high civilization, a culture and learning far in advance of the peoples of northern Europe and the beautiful, well-watered

ship, commencing in 1558, persisted till our own time, when Italy descended upon what was to become a collection of deserts outside the coastal zones and the Gebel. During the latter half of the Moslem period up to the present time there is evidence that the country was becoming drier, less fertile, and the oases were shrinking in size due to encroachments of sand dunes. Under-

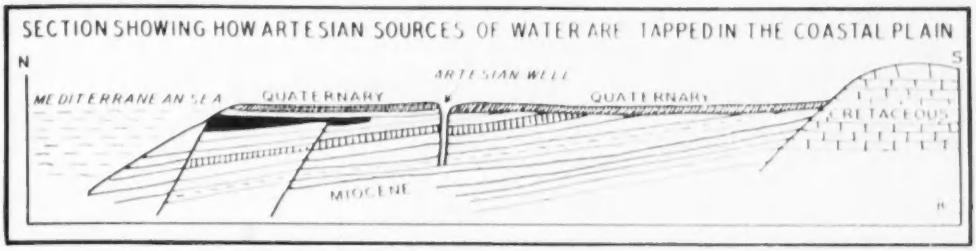

FIGURE 4. Section North to South from Libya, showing how artesian sources of water are tapped in coastal plain.

mining of irrigation works was taking place and towns like Sirte, once a thriving port with a walled city, were disappearing and their quays silting up. Writers of the period were naturally not erosion-conscious as it is understood today, but it is certain that the destruction of the woodland, the scrub and thickets of thorn trees, and the magnificent batum tree, a destruction which penetrated into all the gullies and wadis of the Jebel, was having its natural result even on the resistant fine sandy soils. Olive groves and the date palms were becoming fewer. Furthermore the rainfall must have become less and more erratic over the period and it is likely that a decrease of at least five inches in 2000 years had occurred. Five inches of rainfall represents 500 tons per acre, which means a rate of decrease of half a ton per annum, a decrease which over the centuries has had great influence on the vegetation, the underground water supplies and the area of drifting dunes. The rainfall is now in all probability much more erratic in this country surrounded by treeless wastes, records for many years indicating falls 35 per cent below normal or in some years 90 per cent above. In the one case, even in the best areas of the coastal plains which have a normal of 100 inches per annum, this is a serious matter and winter crops may give a small yield and efforts in the dry summer may fail for lack of irrigation water. The situation in the drier areas is much worse. It is certain that the extra five inches, or an increase of even 12 inches over the normal of our own time, which was likely to occur in the season 5000 years ago, would have made an enormous difference to the productivity of Tripolitania.

No one can tell the amount of decrease which has really occurred over this period of history, but what is now northern Sahara was once inhabited by the Numidian kingdoms, whose cities have been unearthed, as old as predynastic Egypt with whom they traded, and sometimes fought, and where a civilization evolved the first known alphabet and a literature of note.

Their descendants in the mountains, the hill Berbers, still struggle on with their memories and their ancient methods of agriculture. They still build terraces of stone and beaten earth, basin catch pits and storm drains, found so necessary in the earliest days for soil and water conservation, but it is feared that now they are losing their fight, slowly but surely.

Great gullies can be seen beginning in the foothills and escarpment, and when viewed from above great scars are seen in the farms and oases below. Such a large area can be found near Wadi Lebda where numerous Italian settlers are found. Wadi Lebda, now with vertical walls of 80 feet high, was once a smiling valley with farms and a

TABLE I

PRECIPITATION IN TRIPOLITANIA
RAIN SEASON OCTOBER 1943–MARCH 1944

Note: Q is intended to be the monthly total of rain for the season October 1943–March 1944;
M is intended to be the monthly normal mean, as it has resulted in a long period of observations;
K represents the monthly deviation according to the normal average in respect with 1943–44 rain season.

$$K = Q \pm M$$

		Oct.	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*Mar.*	*Total*	*Days of Rain*
					Tripoli Area				
	Q	49.6	194.3	21.2	209.6	68.0	14.7	557.4	58
TRIPOLI, 1911–44	M	36.5	63.9	95.4	78.8	43.9	25.8	344.3	46
	K	13.1	+130.4	74.2	+130.8	+ 24.1	11.1	+213.1	+12
	Q	28.3	165.1	30.5	187.9	64.7	19.0	495.5	56
SIDI MESRI	M	36.7	75.4	85.2	80.0	43.7	35.4	356.4	44
	K	8.4	+ 89.7	54.7	+107.9	+ 21.0	16.4	+139.1	+12
	Q	56.6	122.2	18.0	176.4	87.6	22.6	482.8	58
MIANI	M	54.3	60.6	72.9	75.7	47.2	40.7	351.4	53
	K	+ 1.7	+ 61.6	54.9	+100.7	+ 40.4	18.1	+131.4	+ 5
	Q	76.1	130.5	22.2	148.2	41.5	22.5	441.0	38
TAGIURA	M	34.7	52.8	76.0	87.1	44.3	32.6	327.5	32
	K	+41.4	+ 77.7	53.8	+ 61.1	2.8	10.1	+113.5	+ 6
					Western Province				
	Q	2.0	103.6	48.5	96.1	41.9	19.2	311.3	42
SABRATHA	M	22.7	28.5	33.9	41.0	15.2	22.9	164.2	36
	K	20.7	+ 75.1	+14.6	+ 55.1	+ 26.7	3.7	+147.1	+ 6
	Q	11.0	155.0	45.0	203.0	35.0	11.5	460.5	39
OLIVETI	M	24.5	35.4	65.2	66.1	33.7	32.7	257.6	33
	K	13.5	+119.6	20.2	+136.9	+ 1.3	21.2	+202.9	+ 6
	Q	43.2	119.3	15.8	101.8	55.5	21.3	356.9	48
BIANCHI	M	11.3	20.3	44.0	39.4	23.6	18.1	156.7	29
	K	+31.9	+ 99.0	28.2	+ 62.4	+ 31.9	+ 3.2	+200.2	+19
	Q	36.1	91.5	9.7	100.6	64.0	37.4	339.3	41
MICCA	M	11.3	20.3	44.0	39.4	23.6	18.1	156.7	29
	K	+24.8	+ 71.2	34.3	+ 61.2	+ 40.4	+19.3	+182.6	+12
					Central Province				
	Q	20.8	73.4	8.8	97.2	77.8	36.6	314.6	46
AZIZIA	M	14.1	25.4	55.0	49.3	29.5	23.8	197.1	37
	K	+ 6.7	+ 48.0	46.2	+ 47.9	+ 48.3	+12.8	+117.5	+ 9
	Q	8.3	75.1	8.4	120.1	77.6	39.9	329.4	47
CASTEL BENITO	M	23.2	36.2	64.5	74.2	42.2	22.9	263.2	44
	K	14.9	+ 38.9	56.1	+ 45.9	+ 35.4	+17.0	+ 66.2	7
	Q	4.4	86.6	8.0	148.8	31.4	46.7	325.9	28
GARIAN	M	27.8	40.6	67.0	86.9	54.0	46.0	322.3	36
	K	23.4	+ 46.0	59.0	+ 61.9	22.6	+ 0.7	+ 3.6	8
	Q	2.0	63.5	12.5	192.0	49.5	73.0	392.5	36
TIGRINNA	M	27.8	40.6	67.0	86.9	54.0	46.0	322.3	36
	K	25.8	+ 22.9	54.5	+105.1	4.5	+27.0	+ 70.2	
	Q	3.0	35.0	6.0	282.5	45.0	66.5	438.0	37
ASSABA	M	25.0	36.0	60.0	78.0	49.0	41.0	289.0	33
	K	22.0	1.0	54.0	+204.5	4.0	+25.5	+149.0	+ 4
					Eastern Province				
	Q	10.0	46.0	5.0	99.3	53.5	44.0	257.8	36
ADIAR MEGGI	M	27.0	33.6	51.5	74.7	32.5	25.4	244.7	32
	K	17.0	+ 12.4	46.5	+ 24.6	+ 21.0	+18.6	+ 13.1	+ 4
	Q	8.0	52.4	6.5	141.0	75.2	54.5	337.5	35
TARBUSA	M	25.4	23.3	45.2	64.2	44.3	36.6	238.4	35
	K	17.4	+ 29.0	38.7	+ 76.8	+ 30.9	+18.5	+ 99.1	

TABLE 1.—*Continued*

		Oct.	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*Mar.*	*Total*	*Days of Rain*
					Eastern Province—Continued				
	Q	5.5	58.0	1.5	111.5	82.5	47.0	286.0	38
BREVEGLIERI	M	25.4	23.5	45.2	64.2	44.5	36.0	238.4	35
	K	−19.9	+ 14.7	−43.7	+ 47.3	+ 38.2	+11.0	+ 47.6	+ 3
	Q	10.6	58.0	6.5	125.2	120.9	38.5	359.7	47
MARCONI	M	25.0	40.0	61.0	76.5	48.0	38.0	288.5	41
	K	−14.4	+ 18.0	−54.5	+ 48.7	+ 72.9	+ 0.5	+ 71.2	+ 6
	Q	10.1	91.1	42.4	194.6	110.8	35.3	484.3	49
CORRADINI	M	38.6	33.3	67.8	79.4	30.2	15.5	264.8	28
	K	−28.5	+ 57.8	−25.4	+115.2	+ 80.6	+19.8	+219.5	+21
	Q	5.0	76.0	46.0	137.0	67.0	16.0	347.0	30
HOMS	M	29.7	56.6	55.0	55.2	44.2	19.5	259.6	39
	K	−24.7	+ 20.0	− 9.0	+ 81.8	+ 22.8	− 3.5	+ 87.4	− 9
	Q	17.5	77.0	21.5	84.0	51.5	22.5	274.0	42
GARIBALDI	M	28.1	27.0	49.3	42.2	28.6	15.5	190.7	31
	K	−10.6	+ 50.0	−27.8	+ 41.8	+ 22.9	+ 7.0	+ 83.3	+11
	Q	17.8	111.3	32.2	92.7	45.3	12.7	322.0	58
MISURATA	M	31.6	43.3	46.0	66.7	34.4	10.7	232.7	46
	K	−13.8	+ 68.0	− 8.8	+ 51.0	+ 10.9	+ 2.0	+ 89.3	+12

huge dam which supplied water to ancient Leptis Magna near by. Water, as run-off from the impervious limestone hills, pours through the great wadis, whose soft vertical walls collapse, and the detritus is carried to lower levels to be spread over fertile fields or to reach the sea. In certain large wadis at one time this storm-water penetrated to lower levels of the deep subsoil and soaked the drier plains for the summer sowing, but most of this water is now carried to the sea or to the marshes where the malarial mosquito and salt bushes are dominant features.

It is necessary to give this summary of the past history of agriculture of Tripolitania so that the present situation may be understood in view of the efforts of the past few years to produce better social and economic conditions, efforts somewhat marred by the political and vast military activities, which aimed at making much of Tripolitania a base for storing military equipment and supplies, particularly oil.

Turning again to recent history, the first Italian attack in 1911 on Tripolitania was marked by massacres of the peasant cultivators in the coastal regions, and great flocks of sheep and other livestock were commandeered. A few years afterwards, during the first

FIGURE 5.—Much eroded valley in foothill country of Jebel Nefusa, with small areas of cultivation and a few date palms. Attempts are made to build small terraces in such areas. Elevation 543 feet. (Courtesy of Dr. Cesare Chiesa.)

world war, the Libyan population rose, under the leadership of the Senussi rulers and drove the Italian garrisons back to the coastal areas. The Tripoli plain was occupied again by 1925, but the populations of the Jebel and desert held out until Graziani took command. The repressions of Graziani will long live in the memory of all Barbary. Refugees poured over the frontiers and although many have returned in recent years from Tunisia and Egypt, there were still 60,000 Libyans on Tunisian territory in 1939.

Without entering into all the atrocities of the period, the disturbances among the farming community, the uncertainty of land tenure and even of life itself, the decrease in the number of livestock during the years 1926–33, which the Italians themselves admit was as much as 90 per cent and even the destruction of water supplies by sealing of wells have led to much unsound agriculture, bad soil management with quite inadequate manuring, and without proper upkeep of such terraces which exist. The position was again worsened by the commandeering of 390,000 head of stock for meat and leather for the Italian armies in 1941.

Better things appeared on the horizon when Marshal Balbo became Governor General, and it is greatly to his credit that the majority of the Moslem farmers in particular received attention in so far as water supplies from wells, pumping machines, dune fixation and oases protection, planting of woodland and much extended experimental work. He also took an active part in promoting facilities for education, for medical treatment and transport. During his tenure of office a great stimulus was given to the settlement of Italian farmers, particularly on organized collective settlements, which will be referred to later.

CLIMATE

The climate of northern Tripolitania is of the Mediterranean type, but the nearness of the great Sahara and the Red deserts has considerable influence on the dryness of the whole coastal region over considerable periods. The hot dry winds known as the ghibli also emanates from these deserts, and, when extended over several days, causes considerable loss in crops.

The mountain areas of the Jebel Nefusa gives some protection against

FIGURE 6.—Scattered olive trees at Kussabat in Arab holdings. Some are hundreds of years old. (Courtesy of Dr. Cesare Chiesa.)

TABLE II

RAINFALL OF TRIPOLITANIA (AFTER A. FANTOLI)

J	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*Total for Year*
						Homs (17 Years)						
54.0	46.6	20.1	6.6	5.7	2.6	0.0	0.6	6.3	22.2	58.0	49.7	272.4
						Zuara (14 Years)						
53.3	26.7	20.0	8.3	6.5	0.9	0.0	0.0	4.6	33.5	53.3	40.4	246.9
						Azizia (11 Years)						
51.5	28.3	21.5	6.9	5.6	0.7	0.3	0.1	6.4	13.2	23.6	55.4	213.5
						Garian (10 Years)						
94.4	55.1	47.1	14.2	4.1	3.9	0.0	0.1	10.8	32.2	46.3	67.0	375.2

these winds, the desert influence being most marked to the south and east of the Jebel.

The variation in barometric pressure during summer is influenced by the presence of the low-pressure area which extends over much of the central Mediterranean.

High pressure systems are extensive during the wet winters but well developed depressions traverse the Mediterranean generally from west to east. Under such conditions of alternating high and low pressure the climate is highly variable. Rainfall during the winter is very erratic both in total quantity from one season to another and in the distribution during the season (Figures 8 and 9).

The total for the season may be as high as 90 per cent in excess of normal or as low as 50 per cent below. These rains normally fall from October to March inclusive but in certain seasons there are appreciable local falls in September and April, and on occasions some useful showers in May. The remaining three months are almost invariably dry, temperatures and humidities rising during this period.

Geographical distribution of precipitation depends on the prevailing north-westerly winds reaching the maritime littoral and the Jebel Nefusa, the highest rainfall being 16 inches (407 mms.) in the old town of Tripoli, other high rainfalls, averaging more than 12 inches (305 mms.), being recorded at Garian and Kussabat. The maritime oases outside the Tripoli zone as far as Sabratha in the west and Misurata in the east generally receive a rainfall greater

TABLE III

RAINFALL AT TRIPOLI (AFTER A. FANTOLI)

5 Year Period		*10 Year Period*		*15 Year Period*		*20 Year Period*	
Commencing	*Mms.*	*Commencing*	*Mms.*	*Commencing*	*Mms.*	*Commencing*	*Mms.*
1892	506.7	1892	467.2	1892	449.4	1892	423.2
1897	434.8						
1902	408.2	1902	468.2	1907	456.2		
1907	525.2						
1912	272.6	1912	363.6			1912	355.0
1917	454.7						
1922	388.9	1922	346.2				
1927	303.4						

than 6.5 inches (166 mms.) during the winter (Figure 10 and Table I).

Frost is unknown in all the coastal zones, but at Garian, the average minima in December and January are 7.0 and 5.1° C. respectively. The summer temperatures reach their peak in July and August, with maximum at Tripoli of 34.5 and 35.1° C. and at Garian of 33.3 and 31.8.

Diurnal variation is of importance and this ranges from 12° C. in winter to 16° C. in summer at Tripoli, with a smaller range at Garian and a slightly larger one in the coastal plain (Figures 8 and 9).

Humidities have a large diurnal variation especially in summer when the nights on the coast are somewhat oppressive. The average relative humidity is highest during the winter rains, reaching 70 in Tripoli during February and 56 in Garian during December. During the dry summer, the relative humidity at Tripoli averages 57 rising to 61 in September (Tables II and III).

SOILS AND VEGETATION

Pedological studies have been meager and there are no records of studies of profiles of mature soils. Probably climatic soil types were well exemplified in the soils under the original woodland covering. It is unfortunate that so much erosion has removed the whole of the A horizon and in some cases much of the B horizon from very large areas where once mature fertile soils filled the valleys of the plains and covered gentle slopes in the well-wooded Jebel. Where there has been good rainfall, flat lands and protection against that erosion which has already been described as a curse over long periods of history, there are still mature soils under intensive cultivation. Such are those of the

FIGURE 7.—Group of tamarisk trees in Wadi Sofeggin near Tauorga; elevation 161 feet. Semi-desert zones are frequent at lower elevations. (Courtesy of Dr. Cesare Chiesa.)

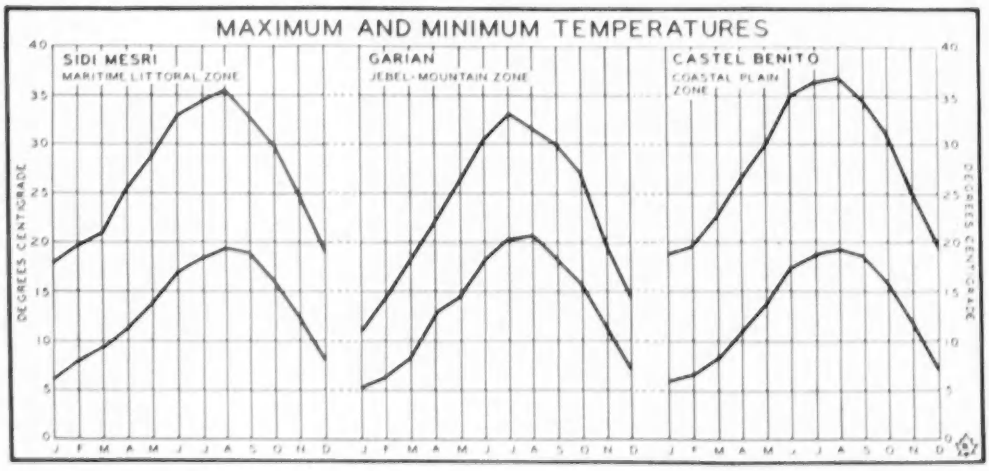

FIGURE 8.—Maximum and minimum temperatures in maritime littoral zone, mountain zone, and coastal plain zone.

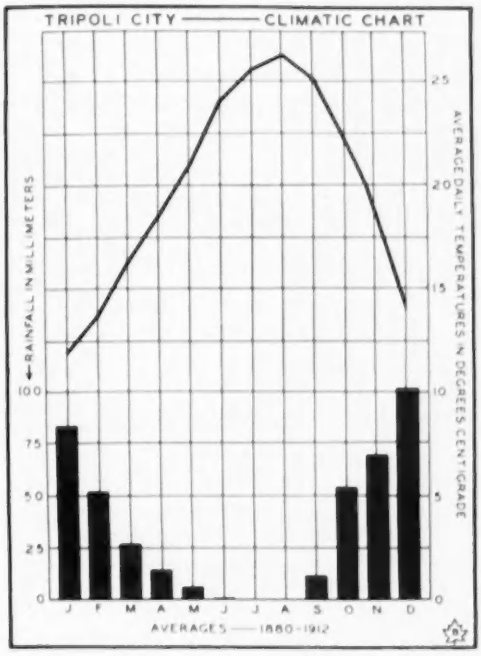
TRIPOLI CITY ——— CLIMATIC CHART
RAINFALL IN MILLIMETERS
AVERAGE DAILY TEMPERATURES IN DEGREES CENTIGRADE
J F M A M J J A S O N D
AVERAGES — 1880-1912

FIGURE 9.—Climatic chart of the city of Tripoli.

general oasis series, of some soils marginal to these, and of the Jebel plateau soils approximating very closely to the terra rossa of other Mediterranean regions. There are numerous local soils of no definite types in all the lands which have been disturbed by considerable run-off and deposition of silty sand in flatter areas and again in the sebcha marsh land areas of the western frontier plains and elsewhere. In the best soils of sparsely populated drier coastal plains, the profiles have been considerably disturbed by the cultivation of the nomads and semi-nomads, who hardly allow the indigenous sand-fixing grasses, shrubs, and geophytes greatly to multiply and minimize wind and water erosion. This part of the coastal plain may soon revert to a cultivation steppe because of the abundance of useless weeds. A classification of the soils can be based on the four main zones, and on the evidence given by the present plant associations, so different from those which existed on the residual soils, such a short period away in pedological time. These associations are characteristic, varying according to the physical properties, the altitude, and the climatic conditions. The latter has also a great influence on what remains of the associations in the winter-flood plains, or great wadis, which were once depressional or valley

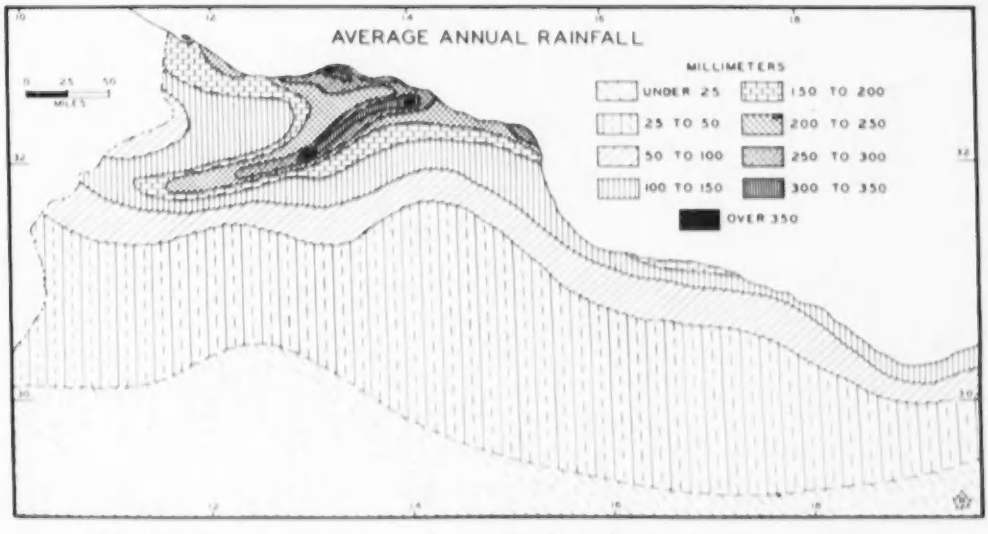

FIGURE 10.—Map showing average annual rainfall in Tripolitania. See Figure 1 for place names.

grasslands around which woodlands and close-growing undergrowth filled the sources and grew densely on the higher land (Figure 11). The magnificent batum tree, *Pistacia atlantica* was dominant in some of these woodlands of the Jebel, *Rhus oxyacantha* the Nefusa sumach in others. White thorn trees, *Acacia karroo*, *A. seyal*, and *A. tortilis* (Figures 12 and 13), together with other thorn trees and shrubs, such as *Calycotome intermedia*, and Christ's thorn which is a *Zizyphus sativa*, must have formed large thorn forests on deep fertile soils at lower elevations. At the lowest elevations, especially where the soils are more clayey and wetter, the woodlands were dominated by the tamarisk, *Tamarix* spp., as all the coastlands of northern Africa once were—even during the wanderings of the Israelites. The presence nowadays only of isolated trees of all the above has been noted. There is no doubt that away from the mature soils with complete profiles still remaining, there is considerable variation everywhere over a short distance, in the depth of what remains of the B horizon, in the covering of wind-blown sand and the content of valuable organic, phosphatic and colloid matter. These variations create many difficulties in fertilizing and experimental work.

The general characteristics of all the cultivated soils is the high percentage of fine sand, the low content of organic matter and total phosphates and the high content of lime, existing from finely divided carbonate to large gravelly masses. Great variations in the amount of these constituents have given rise to some definite plant associations which are identified with definite large areas of land, and which are very prominent in springtime by the numerous and conspicuous flowers. These associations have been termed by some ecologists pseudomacchia of rosemary, thyme, etc., several types of maritime steppe, with and without "cumuli" covered with Christ's thorn, the gerat steppe of *Artemisia herba-alba*, esparto steppe, dune grassland dominated by cotton grass, *Imperata cylindrica*, semi-mobile dune grassland with some woody elements, and *Aristida pungens* with *Retama raetam*, low thorn thickets and bunched scrub dominated by *Calycotome*, and many other associations of the semi-desert itself. The sebcha marshlands are covered with salt bushes, *Salicornia*, *Suaeda*, *Salsola tetragona*, *Limoniastrum monopetalum*, *Iris germanica*, etc. Anyone conversant with these species will realize how inferior the vegetation covering large areas now is.

In order to alleviate the chronic shortage of timber for fuel, poles, buildings, etc., and to improve the vegetation which is so inferior, there was a certain amount of planting of trees in the few years before the war by an Italian military organization, Milizia Nationale Forestale. Attempts were also made in dune fixation and reclamation firstly with the indigenous grasses mentioned above, followed by planting of small trees of exotic species, *Acacia*, *Eucalyptus*, *Casuarina*, and pines. A few hundred acres of these species were also planted and have grown well. With the exception however of these areas and the avenues and private plantations in the better farming areas, the country is deplorably short of timber and it is considered that much more should be done over very wide areas with the species proved of value. This could be done among the villages on a communal basis, just as the notable village forest areas of eastern Africa are managed.

AGRICULTURE

The agriculture of the Moslem farmers, Arab and Berber, actually is the

FIGURE 11.—Vegetation in wadi of coastal plain with large woody element of thorn trees and shrubs. The large trees are species of Acacia: *A. tortilis*, *A. karroo*, and occasionally *A. seyal*. The smaller scrub growth consists of *Zizyphus lotus* rarely reaching 12 feet in height and more usually straggling shrubs which collect much shifting sand. Associated with it are *Calycotome intermedia* and *Tamarix articulata* on certain soils, and also small shrubs of *Capparis rupestris*, *Macruna crassifolia*, *Zella spinosa*, *Retama raetam*. Certain soils on sandy plains of the area also carry associations of *Urginea mastima*, *Asphodedus semipolins*, *Iris germanica*. (Courtesy of Dr. Cesare Chiesa.)

most important in Tripolitania as they number 75,000 souls on the oases and good lands outside these. There are numerous nomadic and semi-nomadic Moslems who range far to the south in the semi-desert and the desert itself. There are 625 Italian farmers on large concessions taken over in the early days of occupation, some as managers, others as share croppers and others as small holders on land of a tobacco company. The settlers with their families under the scheme of the "Colonizzazione demografica" number 9,712 at present, on 1,775 farms and some Moslem farmers under this scheme number 100. This scheme will be dealt with later.

The oasis farming is characterized over wide areas by level fields, which even on gentle slopes has meant great efforts spread over many years. Nearly every small field has a few date palms and water is raised from a well near by. The fields are generally surrounded by a wall of beaten earth on which prickly pear, aloes, thorny capers or Christ's thorn are planted. Some of these walls besides being boundaries serve as protection against running storm water, leading it away gradually. The numerous sunken roads between the fields also assist in dealing with storm water.

The implements used by the Moslem farmers are very primitive, the plough being a simple wooden affair with an iron point. Weeding and cultivation are carried on by hand, knives, and hoes. Weeds are generally collected for forage for the few beasts owned by each farmer.

Many farmers travel to the coastal or even semi-desert plains to grow their cereal crops during the winter and spring periods, returning in the summer with their produce to their permanent homes. These might be termed semi-nomadic and it is quite common in the spring of the year to find an orchard or garden in an oasis or on an ancient bench terrace in the hills the owners being fifteen miles or as much as two days' journey away, where they are harvesting their barley crop in the wadis and more fertile plains and threshing it by age-old methods. In the oases the main winter crops are barley of six-rowed type and

wheat. A biennial crop is capsicum of which there are a few varieties. A little aniseed and cannabis hemp is grown. Summer irrigated crops are maize, pumpkins, watermelons, many vegetables, beans, eggplant, tomatoes, tobacco, sorghum, and millets. In some areas finger millet is favored, while in others pearl millet, and sorghum is favored mostly in eastern areas. Lucerne is largely grown. Great olive trees in number can be seen in the Jebel valleys, particularly at Kussabat, some being hundreds of years old. Of fruits, figs, mulberries, pomegranates, almonds are grown in small patches, often close to the well itself. There are a few carob trees, but bananas and other fruits common in the sub-tropics are rare. The fruits of the prickly pear are also eaten. Henna plantings are often seen. Tobacco is a valuable cash crop, the cultivation of which is regulated by monopoly legislation. More might be done with plantings of well-budded citrus as a food and money crop.

Mention might be made of the troglodyte farmers near Garian in the Jebel. They live in large square holes dug in the calcareous red earth, in the sides of which have been excavated living quarters, storehouses, and stables. Entrance is effected by a tunnel. History records the existence of troglodyte peoples far to the south of the present semi-desert. It would be interesting to know if these people were the ancestors of the present ones, who, with increasing desiccation, migrated to the present sites.

Improvements and assistance to all the Moslem farmers are easily visualized. Better implements and fertilizers could be obtained coöperatively as in the case of the 100 settlers mentioned above. Coöperation or control in marketing certain produce could be introduced with advantage. The better utilization of waste products could be done with great advantage all round, resulting in better sanitation, in less fly menace and spread of trachoma, and in greater fertility. Improvement in varieties of crops grown or the introduction of better varieties such as with the millets could be done. In certain cases some improvement in stock and treatment of a few diseases in animals, especially intestinal parasites could be carried out. The root gall worm in certain plants is a great pest and in the intensively cultivated areas, certain seasons lead to leaf and root diseases. There is much work for plant pathologists.

COLLECTIVE SETTLEMENTS

The stimulus given during the regime of Marshal Balbo to collective settlements or groups of coöperative small holdings has been referred to. Under the aegis of concession holders such as the Azienda Tobacchi Italiani and la Valdagno, before 1935, there were groups of small holders who worked in cooperation, utilizing various cash crops such as tobacco, grapevines, and groundnuts, in the economy of the farm. Later, spread over a period up to 1939, most of the settlers arriving in the last two years of this period, these collective settlements commenced under what looked like the most favorable auspices of governmental support and active participation, and they appeared to embody all those principles underlying the real success of colonization of this order.

Settlers were carefully chosen by the Fascist authorities in Italy and were received on prepared holdings, whose size and whose homesteads, buildings, implements, etc., varied in each group. Roads and wells were everywhere provided and the settlements were grouped around a center which catered to the cultural, health, spiritual, and recreational needs of the settlers.

It is important to note that these blocks of land acquired by the government and handed over to the central organization, the most important of which is the Ente per la Colonizzazione della Libia, were considered after a survey to be of such a size and with such conditions of soil, climate, water supply, and vegetation, that, in course of time, the settler would eventually become the happy and contented owner of his holding, free from debt and assured of a prosperous future for himself and his family.

The settler was financed in the early days after arrival and the Ente concern was entitled to all the produce of the cash crops, other crops such as vegetables and fruits, dairy and poultry produce being mostly consumed by the family. After two to three years of this, during which the settler received a small salary adequate to keep the family in food, clothing, etc., he became a partner in the enterprise, being credited with half the proceeds of the sale of the cash crops. This credit period was to have lasted several years until the community manager and the central organization decided that the settler could operate on his own.

Nearly all these collective settlements, in nine "Ente" groups, called by the Fascists "demographica" have not had time to pass the second stage and the war has precluded several of the older men from becoming independent.

During the second stage, efforts are made to develop the holding and to pay off the debts incurred on behalf of the settler during the early periods, payments varying according to the results of the greatly varying seasons. This program sounds very much like those visualized in some of the collective settlements in the United States such as Penderlea, sponsored by the Farm Security Administration during the past 15 years.

Another organization called the Instituto Nationale Fascista della Providenza Sociale also assisted settlers in eight groups on a similar basis, commencing one in 1935, others in 1938–39, which need not be dealt with in detail, but it must be noted that all these collective settlements altogether do not contain more than 2000 holdings or family farms, which cover 144,500 acres and that few are independent or are likely to be, when working for their livelihood on the average acreage of 80, during the years when the seasonal rainfall is only normal or below such a figure and when no locust infestation or desiccating ghibli winds come to destroy crops.

In view of the principles which must be observed in the establishment of sound and successful settlements of this order, it is here necessary to state that all the settlements are situated in zones with a Mediterranean climate, in parts inferior, which have been described above and where the soil series covering the areas were either of the marginal oasis type or more largely fine sandy soils of low fertility. On no settlements were there appreciable areas of soils of medium to high fertility and moreover to minimize the abnormal soil erosion which can be seen on many settlements, no arrangements, recognized as standard in all progressive countries of the world, can be seen.

The whole scheme during the past eight or nine years has not been stabilized on a good foundation, and it is doubtful if the agricultural authorities, who were responsible for the position, and the size of the holding which would be managed by the settler and his family, had made an adequate survey of the soils, the climate and agro-economic factors, which would make for

highly successful results under the set of conditions on each holding.

CROPS

Passing from the above to the particular crops which were specified to be grown by the settler, olive trees received most attention, but unfortunately under the average conditions, it takes at least ten years for the trees to yield a payable crop. Some return is obtained from crops interplanted in the groves such as cereals and grapevines. The latter again has been a great feature when planted alone, but with a return to normal conditions it is doubtful if grapes, either for food or wine-making will be a prominent feature in the economy of the farm of 80 acres. In 1943 the crop was decimated by the ghibli, the hot dry wind blowing fiercely from the Sahara in August and there was much loss from locusts this year. In Algeria, moreover, there has been considerable financial loss from grapevine culture under similar Mediterranean conditions.

Wheat was specified as the main food crop to be grown, although the Moslem farmers after centuries of experience grow much more six-rowed barley during the winter periods with their erratic rainfall. The settlers are in a favorable position to produce cereals for their own consumption in seasons of good rainfall owing to the machines they may use in coöperation and the low value which may be put on their own efforts, but when the high cost of fertilizers, manuring, and rotations are taken into consideration and when their time may be spent more profitably on other labors, especially during seasons of low yield combined with the low cost of flour in normal times from the great wheat-growing countries of temperate climates, the production is quite uneconomic. This is indeed the case in all subtropical regions, which are free from frosts, where a maritime littoral and coastal plain are covered almost entirely with sands of low fertility and where the rainfall is very erratic.

Air-cured tobacco is a crop which in all likelihood will be profitable for some time. There is a large market locally and the production is carefully regulated at present under a monopoly. It

FIGURE 12.—Groups of *Acacia tortilis* and *Pistacia atlantica* in depression and flood grassland with woody elements in Wadi Sofeggin. These must have formed considerable forests in wadis, depressional flood grasslands in the coastal plains, more fertile areas of lower zones of Jebel Nefusa, and in the plateaus of semi-desert in ancient times. (Courtesy of Dr. Cesare Chiesa.)

TABLE IV

POPULATION

Province	*Moslem Arabs and Berbers*	*Italian Colonists*	*Others of Italian Nationality*	*Jewish*
Eastern	253,320	5,489	1,092	3,853
Tripoli	195,952	390	23,600	19,742
Central	122,580	.....	1,450	1,024
Western	127,598	3,833	2,990	1,666
Totals	699,450	9,712	29,132	26,285

is a crop which will repay careful attention to the soil from the point of view of fertilizing, manuring and rotations.

Manuring is of the utmost importance in all the crop production of these settlements and with the shortage of stock which has resulted from causes referred to above. The problem of getting any of the holdings on a correct animal-crop balance, important as it is, is now difficult, especially as any stock is high-priced at present. This is doubly unfortunate as irrigation is available on most holdings for forage crops such as lucerne.

Little reference need be made to other crops such as groundnuts, fibres, a few castor oil trees, essential oil plants, and the vegetables for sale in local markets, but in the latter case such production has to compete with that produced by Moslem farmers in the more fertile oases. It seems that it will be many years before any of these settlers will be prosperous farmers and then perhaps only by combining some of the holdings and introducing quite a different system of agriculture when conditions return to normal after the war and its aftermath.

Mention might be made of the need of much greater production of protective foods for the family of the average settler, but when this and all the other problems are considered, it can easily be seen how utterly impossible it would have been to accomplish the settlement of 100,000 people on the land in Libya in 1942 or in another 25 years, a further 250,000. The aims underlying such a Fascist scheme can be imagined, but cannot be openly stated.

POPULATION

The total population of Northern Tripolitania is 764,579 (Table IV). Of of these 170,000 Moslems, 21,000 Italians, and 19,500 Jews are urban dwellers, mostly in Tripoli and its suburban oases.

The number of farmers actually identified with house, land and stock are approximately 75,000 Arabs, Jews, and Berbers, and 2,130 Italian colonist and other farmers. There are about 250,000 nomadic or semi-nomadic Moslems of different and mixed race but there is a great variety in the modes of life and kinds of migration among these people. There is now a greater tendency towards sedentation which increases the problems in the oases and urban centers, where numerous miserable habitations and tents are to be found on the outskirts. It will be noted that four-fifths of the population are rural.

Population densities are very variable. In the more fertile areas, which include the oases, there are approximately 325 persons to the square mile. In the areas where fine sandy soils of the coastal plain are in a medium state of fertility, there are about 10 persons to the square mile. In all other areas of the hill regions and coastal plain with

TABLE V

DISTRIBUTION OF POPULATION, 1935 ACCORDING TO A. FANTOLI

234,000	in Maritime littoral
32,000*	in Coastal plains
174,000*	in Gebel Nefusa, scarp lands, valleys, etc.
41,000*	in semi-desert.
78,000	in desert.
559,000	

*Pastoral nomads and semi-nomads ½ to ¾.

FIGURE 13.—*Acacia tortilis* trees on flats, with scrub of *Zizyphus lotus*, and species of *Retama* in Wadi Sofeggin. Elevation 975 feet. Wadi Sofeggin. (Courtesy of Dr. Cesare Chiesa.)

poor sandy soils and rocky outcrops, there is hardly one to the square mile. Doubtless much of Northern Tripolitania has reached saturation capacity (Table V).

LIVESTOCK

The small numbers of livestock in the country have been referred to. There are approximately 200,000 goats, 150,000 sheep, 24,000 cattle, 20,000 camels, 20,000 donkeys, and 500 each of mules and pigs.

The grazing areas are very poor and the country can never support vast herds. Fortunately for the small holder who owns a few head of stock, there are practically no diseases which are serious disabilities and cannot be controlled with some small veterinary assistance. There is doubtless room for increased herds of cattle and sheep, provided the increase can be fitted in with a better utilization of the grazing lands and an increased production of forage crops by irrigation and manuring. Goats may be specially mentioned as the cause of much further damage in the already denuded and eroded grazing lands, which can no longer support cattle or sheep. Here, as elsewhere, some authorities would go so far as to place a ban on goat farming.

As an example of the numbers of stock the country could once support, the following case may be cited. The Roman General Ammien Marcellin in A.D. 363 caused the city and province of Leptis Magna to deliver 4,000 camels for the rationing of his army, which was promptly accomplished. Libyan elephants were beginning to disappear about this time, due partly to the destruction of forests, their natural grazing areas, to the smaller use to which they were put by the occupying power and to slaughtering for food. At this time also Tertullien has testified: "the deserts are effacing the most famous smiling domains, the cultivated fields encroach into the forests, the sheep have put to flight the wild beasts."

INDUSTRIES AND TRADE

The industries of Tripolitania are few in number, which is surprising when the urban populations of Tripoli City totalling 126,000 and of other small centers, such as Misurata, are taken into consideration. Many of these industries are correlated with agriculture and the oasis suburbs of these urban centers are peopled by market gardeners and small holders, who do well out of the market near by, in preparation of foodstuffs, sale of vegetables and in horse-drawn and other transport which reaches large dimensions.

Natural resources upon which industries depend are few. The following may be noted: tobacco, vegetable oils, tunny and other fish, wool, fibers, hides and skins, sponges, limestone for building, and clay for brickmaking. Some of these are utilized in local home industries and handicrafts which may become much handicapped by the importation of materials made elsewhere by modern methods and machinery. Such are the manufacture of textiles,

carpets, wool barracans (the universal overalls), and even soap.

Among other minor industries which can eventually be more developed are the leather, paper from esparto grass, brickmaking, and making of locally popular boots and shoes.

There is also the large wine production, some small distilleries of spirit from wine and fermented dates, a large brewery utilizing imported barley malt, and notably the large factory for manufacture of cigarettes, snuffs, etc.

The tunny fisheries are of great importance, some 300 tons of canned meat being produced during the last season.

Tourist traffic was of great value to this country once and with the coming of peace and the advent of great airlines across Africa, this traffic may eventually be again of great potentiality.

Trade at the present time is abnormal owing to war conditions, but a reversion to prewar conditions is expected in the near future. As part of the former Colony of Libya, which has never been a sound financial proposition, the following figures are of interest. In 1935, the exports of Libya were worth 61,000,000 lire, and the imports 398,000,000 lire—or six and a half times as much. The imports of Tripolitania were normally worth about five times her exports. These accounts do not include military stores or cost of fortifications. Matters should be much better in the future, but in years of normal rainfall, it is likely that subsidies will be required to preserve the country from a parlous economic state.

CONCLUSION

From the foregoing study of this country which has a maritime littoral and coastal plain with a climate drier than those of most other Mediterranean countries, it will have been seen that numerous problems have arisen in its far-distant and more important past and are arising at the present time. The main problem, even with the small population, is how the population and livestock can be maintained on its own resources not only during the seasons of normal rainfall but also when the rainfall during the growing season is far below normal. Increased yields and better health of stock can be obtained by those methods which have been outlined. Even in a country where a very large staff has been studying the agricultural problems for years, namely South Africa, it has been found necessary to review and to ask for early action on such matters as economic disabilities, labor inefficiency, unorganized settlement, social security, better methods of land use, more effective soil conservation, reclamation, need for surveys such as an extended agro-economic survey, etc. Few countries in Africa would not be better off economically for such a thorough survey and the progress which would result from action taken in accordance with its findings. This unfortunately may take some years to attain. Political considerations do not concern this review, but it is hoped that when the future of this and other Mediterranean countries is decided, they may go forward in unison.

THE WASHINGTON APPLE INDUSTRY

II. ECONOMIC CONSIDERATIONS

Rayburn D. Tousley and Hoyt Lemons

In Part I of this study, the geographic basis of the Washington apple industry was discussed with the view of indicating the favorable production factors that have led to its development. It was concluded that, although changing geographic conditions have probably resulted in somewhat higher costs of production during recent years, the problems of the industry have arisen primarily from economic changes in the competitive situation and the extent of demand for the product.

It is the purpose of the second part of this study to show the extent of the economic problem, to point out the causes of the industry's decline, and to discuss briefly some of the possible solutions that have been considered by the industry from time to time. It is hoped that this discussion will serve to re-emphasize the fact that additional effort must be expended if a satisfactory peacetime solution to the problems of the industry is to be found.

Development of the Industry

Washington apple production began on family orchards as a part of general subsistence farming. By the early 1890's a few shipments were being made to distant points, and Washington's first million-bushel apple crop was attained in 1895. By 1898 production had increased to 2,000,000 bushels, and in 1906 it reached the 3,000,000-bushel mark. At this time, the future of the Washington apple industry appeared bright indeed. There seemed to be no limit to the eastern market. Returns to growers ranged from $500 to $1500 per acre, and a news item in 1909 reported the purchase of a car of apples by a New York dealer at a price which averaged $.08 per apple.

Although minor setbacks occurred from time to time in the form of price declines, the Washington apple industry continued to expand rapidly. During the five-year period 1911–1915, average annual production was 7,500,000 bushels. New orchards came into production in 1916, and the crop of that year exceeded 16,000,000 bushels. By 1919 production had increased to 25,000,000 bushels; in 1923 it amounted to 33,000,000 bushels; and in 1930 Washington produced its peak crop of 38,000,000 bushels, almost 25 per cent of the total United States production. Table I shows the growth of the Washington apple industry after 1916.

Evidences of Decline

The data in Table I also indicate the extent to which production of the Washington apple industry has been reduced since its peak year of 1930. Although average total production for the five-year period 1931–1935 shows only a five per cent decrease in relation to the 1926–1930 period, commercial production decreased 16 per cent and car-lot shipments 18 per cent. Comparing the period 1936–1938 with the period 1926–1930, average total production was down 12.5 per cent, commercial production 20 per cent, and shipments 25 per cent. Shipments declined even

more substantially during 1939 and 1940. It thus seems obvious that during the 1930's it was becoming increasingly difficult to find satisfactory markets and that a greater proportion of the crop was being disposed of in other than fresh fruit channels, if at all. This indicates a smaller return to the grower since fresh fruit channels are the most profitable.

The decline of the Washington apple industry since 1930 also can be shown by the decrease that has taken place in the number of trees. In Table II are presented Census data for 1930, 1935, and 1940 with respect to the number of apple trees both in Washington and in the United States.

According to these data, the decrease in trees of bearing age between 1930 and 1940 has been 34.5 per cent both for Washington and for the United States as a whole. Thus general nation-wide discouragement over the apple situation is indicated. However, the decrease in trees not of bearing age between these two years amounted to almost 51 per cent for the United States as a whole and to 71 per cent for Washington. This greater failure to replant would appear to show more pessimism on the part of Washington growers than of growers as a whole in so far as the future of the apple industry is concerned. Much more significant, however, is the fact that almost three-fourths of the nation-wide decrease in trees not of bearing age took place between 1930 and 1935, whereas almost seven-eighths of the decrease for Washington came between 1935 and 1940. This tremendous decline after 1935, despite the return of a moderate degree of general prosperity during the late 1930's, indicates that the problems of the Washington industry arose to a large extent from economic conditions within the industry itself. These conditions have their origin in changes which have taken place between 1930 and 1940 in basic production and marketing processes.

PRODUCTION FACTORS

One of the most important production advantages of the Washington apple industry has always been the high yields per tree and per acre. According to Census data, the average yield of apples per tree of bearing age for the entire United States was 1.5 bushels in 1935 and 2.6 bushels in 1940. By contrast, Washington growers had an average yield of 6.7 and 6.9 bushels respectively. Of course, the average yield per tree in the eastern regions is brought down by the existence of many small and carelessly tended orchards conducted on a part-time basis; but it is probable that production per tree in Washington is at least twice that of comparable commercial areas in eastern states. On a per acre basis, production in Washington is even more favorable because there are more trees per acre in Washington than in the eastern states. The U. S. Department of Agriculture gives a figure of 50 per cent more trees per acre in the Wenatchee area than in certain regions of Michigan and New York.

Washington's production advantages, discussed in the first part of this study, may be enumerated as follows: (1) a natural soil fertility that leads to high yields, (2) a favorable climate which gives a regular crop and well-colored fruit, and (3) irrigated farming which leads to more rapid growth, a greater yield, and larger-sized fruit. These advantages helped to overcome the handicap of distance from markets during the early stages of development of the Washington apple industry.

Since 1925, however, it is doubtful that Washington growers have been able to produce apples at a lower cost than have eastern and middle western grow-

ers. In the first place, the latter have made improvements in production methods which have reduced their costs. In the second place, certain costs of Washington growers, notably those connected with spraying, have increased during the past 15 years. It is difficult to determine, in fact, whether Washington production costs have ever been substantially below those of other areas. Perhaps the principal production advantage of the Washington industry has always been the quality of the fruit grown. In any event, there are at present three production costs incurred by Washington growers which appear to offset completely the advantages derived from high yields. These are the cost of irrigation, the cost of spraying, and the cost of thinning.

Expense of irrigation is a substantial cost element which must be borne by Washington growers but which is nonexistent in eastern and middle western orchards. A study by Neil W. Johnson, covering the three years 1926–1928, reported that irrigation costs in the Yakima area, including interest and depreciation, amounted to $13.73 per acre in overhead costs and $12.04 per acre in labor expense. Corresponding costs for the Wenatchee area amounted to $20.44 and $17.58. With an average production per acre on the farms studied,

TABLE 1

TOTAL PRODUCTION, COMMERCIAL PRODUCTION, AND CAR-LOT SHIPMENTS OF WASHINGTON APPLES, 1916–1940

Crop Year	*Total Production*		*Commercial Production*[1]		*Car-lot Shipments*	
	1,000 bu.		*1,000 bu.*		*Carloads*	
1916	16,560		[2]		14,426	
1917	18,360		[2]		15,847	
1918	19,592		[2]		16,232	
1919	25,295		21,501		27,023	
1920	18,300		17,202		22,213	
5-year average		19,621				19,146
1921	31,500		24,900		33,355	
1922	27,449		22,023		28,291	
1923	33,000		28,800		37,633	
1924	22,000		19,500		25,156	
1925	28,700		26,010		35,046	
5-year average		28,530		24,247		31,896
1926	34,445		25,950		34,729	
1927	24,940		22,302		30,280	
1928	37,846		30,900		41,317	
1929	30,000		24,800		34,220	
1930	38,000		33,900		45,217	
5-year average		33,045		27,570		37,133
1931	31,000		25,893		34,558	
1932	32,000		23,317		30,822	
1933	29,240		20,000		26,311	
1934	33,026		24,850		32,887	
1935	32,208		21,362		27,737	
5-year average		31,495		23,084		30,463
1936	27,294		21,600		28,397	
1937	30,012		22,330		27,840	
1938	29,410		22,400		27,711	
1939	[3]		[3]		22,226	
1940					23,959	
5-year average		28,905[4]		22,110		26,027

[1] "Commercial production" here means sales for consumption as fresh fruit.
[2] Not available before 1919.
[3] Series discontinued after 1938.
[4] Three-year average.
Source: Bureau of Agricultural Economics, U. S. Department of Agriculture, December, 1944. Averages computed by the writers.

TABLE II

NUMBER OF APPLE TREES IN THE UNITED STATES AND IN WASHINGTON, 1930, 1935, 1940

(in thousands)

Year	United States			Washington		
	Of Bearing Age	Not of Bearing Age	Total	Of Bearing Age	Not of Bearing Age	Total
1930	88,849	27,455	116,304	5,194	948	6,142
1935	82,535	17,519	100,054	4,598	859	5,457
1940	58,152	13,511	71,663	3,404	272	3,676
% decline 1940 in relation to 1930	34.5	50.8	38.4	34.5	71.3	40.1

Source: *Sixteenth Census of the United States, 1940, Agriculture*, Vol. III, p. 842. Percentages computed by the writers.

of 484 in Yakima, and 536 in Wenatchee (a western apple box is approximately equivalent to a bushel), irrigation costs per box were approximately $.0533 in Yakima and $.07 in Wenatchee. This cost was probably somewhat lower during the decade of the 1930's because of lower wage rates.

A second cost of considerable importance is that of spraying. Johnson found the cost of materials and labor to be $31.49 per acre in Yakima and $39.48 in Wenatchee, or $.065 and $.074 per box respectively. The corresponding cost for orchards in Niagara County, New York, during the same period (1926–1928) was $15.14 per acre. Because of lower yields, however, the cost per bushel in New York was almost $.13. Since 1930, the cost of spraying in Washington has increased substantially while remaining relatively constant in New York. The Department of Agriculture estimated the cost of spray materials and labor during 1940 in Wenatchee at $55.30 per acre and in Niagara County at $15.00 per acre.

A third production cost which is important in Washington and either nonexistent or nominal in eastern regions is the cost of thinning. Johnson found the labor cost of thinning to be $21.78 per acre in Yakima and $31.36 in Wenatchee. The Department of Agriculture estimated the cost during 1940 in Wenatchee at $24.00 per acre.

In the final accounting, there appears to be little difference in production cost between Washington and the eastern states. On the basis of Johnson's data, the Department of Agriculture computes production costs (i.e. growing cost, not including cost of harvesting, packing, or selling) exclusive of interest during the years 1926–1928 at $.40 per bushel in Wenatchee and at $.417 in Niagara County, New York. Using this same basis, production cost in Yakima would have been from $.05 to $.09 per bushel less than in Wenatchee. A study of Berrien County, Michigan, in 1935 arrived at a comparable figure of $.269. For 1940 the Department of Agriculture estimated production cost in Wenatchee at $.355 and in Niagara County at $.356. None of these figures include interest on investment.

Although the above data are not complete, they indicate that Washington production costs are not significantly below those of other areas and that they may even be above the costs of other regions in some instances.

MARKETING COSTS

The Washington apple grower has always suffered from the handicap of distance from the large consuming markets of the East and Middle West. This greater distance, of course, has resulted in much higher transportation charges than have been borne by his

local competitor. To overcome this handicap, the Washington grower has made an effort to place on the market an attractive product, carefully packed and properly graded and sized.

Thus at an early date, Washington growers began specializing in high quality apples of a few varieties which were in demand in distant markets. This aided in establishing a reputation for Washington apples which in turn helped maintain higher prices and sales in competition with local apples. Maintenance of this reputation required greater care in producing and handling than would otherwise have been necessary. Thinning, pruning, and spraying of trees produced larger apples and better yields. Apples were picked carefully and at the correct maturity for color, flavor, and keeping quality. They were carefully washed of spray residue, graded, and packed in sterilized boxes. Immediate precooling and storage in refrigerated warehouses kept apples in prime condition for sale at a later time after local apples had disappeared from eastern markets.

Thus the marketing costs of the Washington grower, aside from any question of transportation, have always been higher than those of eastern and middle western growers. During the decade of the 1930's, harvesting and packing costs—which include picking, grading, hauling, washing, sorting, and packing—amounted to almost $.50 per box; and shipping point storage and warehousing on the average added from $.11 to $.15 more. Although complete studies have not been made of harvesting and packing costs in eastern regions, the Department of Agriculture estimated costs in 1940 at about $.35 to $.38 for a packed bushel basket. The cost to many farmers would undoubtedly be less because many eastern growers have not attempted in the past to put up a pack comparable to that of western growers. But even for a comparable pack the cost in eastern states is at least $.10 to $.12 less than it is in Washington. Storage charges are approximately the same in both regions when apples are actually placed in storage, but a much smaller proportion of eastern apples goes into storage (especially into cold storage) than of western apples. Washington must dispose of much of its apple crop *after* local apples have been sold and are no longer available.

Since selling charges do not vary greatly between the two regions, amounting to $.10 or $.11 per bushel for both areas in normal times, there remains to be considered the item of transportation as the principal cost factor. It is difficult to determine a typical freight rate for Washington apples, since rates are changed from time to time as are the arbitrary weights assigned to a box of apples for billing purposes. On the whole, however, it may be stated that the cost of transportation to a point east of the Rocky mountains would not be below $.40 per box and would range upward to $.55 or more. This cost may be compared with an average transportation cost for New York apples of perhaps $.20 per bushel. In addition, many shipments of Washington apples have to bear certain railroad service charges such as icing, refrigeration, ventilation, and heating. The average cost for such services for all apples shipped has been found to be about $.03 per box, but when one of these services must be utilized, the actual charge is between $.05 and $.06 per box.

The above data indicate that Washington apples, even with the most favorable freight rates, are under a cost handicap of from $.40 to $.60 per bushel in most markets when competing with local apples of comparable pack. And

these higher marketing costs are not offset appreciably by lower production costs.

RETURNS TO GROWERS

Although the cost data presented above are incomplete, and for some items even fragmentary, they are probably sufficiently accurate to demonstrate that the Washington grower did not receive his cost of production (including marketing costs) during the decade of the 1930's. It appears that the average net-to-grower price during this period would have had to average between $.80 and $.85 per bushel to cover what were virtually his out-of-pocket costs. If production cost is estimated on the average at $.35 per bushel and harvesting and packing costs at $.50, the total amounts to $.85. Total costs actually may have been a little less than this, and undoubtedly were less during the worst years of the depression, but they could hardly have been below $.80 on the average for the entire decade.

It is evident from the data in Table III that an average price higher than this estimated cost of production was realized in only four of the 11 years between 1930 and 1940. Moreover, during four years the average price per bushel was below $.70.

TABLE III

SEASON AVERAGE PRICE PER BUSHEL RECEIVED BY GROWERS FOR WASHINGTON APPLES, 1930–1940

Crop Year	*Price (in cents)*
1930	104
1931	65
1932	55
1933	83
1934	71
1935	70
1936	109
1937	62
1938	84
1939	69
1940	78

Source: Bureau of Agricultural Economics, Washington, D. C.

These figures are, of course, averages and have all of the limitations of averages. It must be realized that certain varieties, grades, and sizes brought prices sufficiently high to cover costs. Also, some producers with low costs and a large percentage of favorable grades and sizes made a satisfactory profit at most of the above prices. Nevertheless, it was estimated by the Department of Agriculture in 1940 that, on the basis of 1934–1937 average prices, added returns of at least $.15, perhaps as much as $.25, per box were required to meet the production, harvesting, and packing costs of most Washington growers. Added returns of $.15 per box during the period 1934–1937 would have given a net-to-grower price of about $.95. This is $.15 above the minimum out-of-pocket cost estimate made above. Including interest on investment and a return for the farmer's own labor, it would appear that such a price would be none too high. This would not be sufficient to keep many marginal and sub-marginal growers in business, but it would probably keep in production most of the well-located, well-managed orchards which are growing desirable market varieties.

CAUSES OF THE WASHINGTON APPLE PROBLEM

We have noted the decline which took place in the Washington apple industry during the decade of the 1930's. We have also seen that the prices received for Washington apples even during the latter part of the decade were not sufficient on the average to cover production and marketing costs. Obviously certain changes have taken place which caused a rapidly developing industry to approach a state of near economic collapse. What are these changes and to what extent do they

represent permanent developments in the economic structure of the industry?

The influence of the depression of the early 1930's undoubtedly was substantial. Sharply reduced prices resulted from the low level of general business activity and threw into confusion an industry already faced with a slowly but steadily declining market. As previously indicated, however, the writers do not believe that the permanent solution to the Washington apple problem is to be found merely in a return to relatively prosperous times. The continued decline in production and shipments after 1935 and the almost complete failure to replant between 1935 and 1940 show the influence of certain long-run developments with which the industry must cope. These developments are (1) a declining consumption trend for apples in general which has probably been caused, in part at least, by the competition of other fruits; and (2) increasing competition from local apples in eastern and middle western markets.

Changes in Consumption

Although it is difficult to measure the consumption of fresh fruits, since consumption data for such products must necessarily be implied from production figures, there is little doubt that the consumption of apples throughout the United States has declined steadily since 1915. This is shown most clearly by the data on per capita consumption (Table IV and Figure 1).

In 1909 the per capita consumption of apples was 63.8 pounds; by 1939 it had decreased to 40.8 pounds. The lowest point in per capita consumption was reached in 1934 with the amount of 36.6 pounds. During the later 1930's a slight increase took place, but the per capita consumption of apples in 1939 was still 36 per cent below that of 1909; and the average consumption for the five years 1935–1939 was 37 per cent below the average for the period 1909–1913.

The data in Table IV also indicate some of the products which apparently have taken the place of apples in the diet of the American consumer. Canned fruits increased in per capita consumption by 283 per cent between the 1909–1913 and 1935–1939 periods. The consumption of dried fruits increased by 50 per cent, and the consumption of fruit juices increased from a very nominal figure to one of significant proportions.

But of even greater importance in total volume is the increase in the consumption of citrus fruits from an average of 18.7 pounds per capita in the

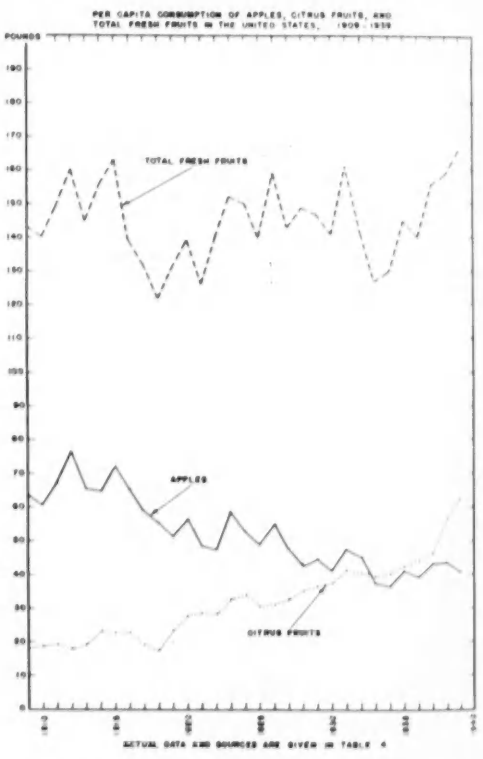
PER CAPITA CONSUMPTION OF APPLES, CITRUS FRUITS, AND TOTAL FRESH FRUITS IN THE UNITED STATES, 1909-1939
POUNDS
TOTAL FRESH FRUITS
APPLES
CITRUS FRUITS

FIGURE 1. During the period from 1909 to 1939 the per capita consumption of fresh fruits remained relatively constant. Meanwhile the per capita consumption of citrus fruits increased while that of apples declined.

TABLE IV

PER CAPITA CONSUMPTION OF FRUITS AND FRUIT JUICES* IN THE UNITED STATES, 1909–1939

(in pounds)

Year	Fresh				Canned	Dried	Juices	Total, in terms of fresh
	Apples	Citrus Fruits	Other	Total				
1909	63.8	18.2	60.8	143	3.1	3.9	0.4	162
1910	60.8	18.7	60.3	140	3.2	3.7	0.3	159
1911	67.2	19.4	62.6	149	3.5	3.9	0.3	168
1912	76.1	18.0	66.1	160	4.1	4.3	0.4	181
1913	65.6	19.4	59.6	145	4.2	4.0	0.2	165
1914	64.9	23.6	67.9	156	4.7	4.0	0.3	178
1915	72.1	22.9	68.1	163	5.2	4.6	0.5	188
1916	65.3	22.8	50.5	139	5.6	1.5	0.3	166
1917	59.0	19.2	53.4	132	6.8	5.6	0.3	162
1918	55.4	17.6	48.8	122	7.5	5.4	0.3	153
1919	51.6	23.5	55.8	131	8.7	5.7	0.4	164
1920	56.1	27.9	55.4	139	9.2	6.7	0.4	176
1921	48.5	28.5	48.6	126	8.0	6.2	0.2	158
1922	47.4	28.2	64.2	140	7.8	6.0	0.2	171
1923	58.4	32.7	60.9	152	8.5	6.1	0.2	185
1924	52.7	34.0	63.7	150	8.4	6.2	0.1	183
1925	48.9	30.6	60.8	140	10.2	6.5	0.1	176
1926	54.7	31.5	72.4	159	11.8	6.3	0.2	196
1927	47.9	32.4	62.5	143	12.2	6.2	0.2	180
1928	42.4	35.2	71.8	149	13.2	6.1	0.2	188
1929	44.6	36.3	66.5	147	12.6	5.7	0.3	184
1930	41.4	37.9	62.1	141	12.0	5.4	0.3	176
1931	47.5	41.5	71.6	161	11.5	5.2	0.4	194
1932	45.4	40.7	55.0	141	9.7	5.2	0.4	172
1933	37.8	39.8	48.9	127	10.8	5.5	0.4	160
1934	36.6	40.1	53.6	130	12.4	5.5	0.8	167
1935	41.2	42.1	61.4	145	11.9	5.8	2.0	184
1936	39.8	44.3	56.0	140	14.1	5.8	3.6	185
1937	43.4	46.2	66.7	156	15.2	5.8	4.8	205
1938	43.9	56.3	59.1	159	12.9	6.0	5.0	206
1939	40.8	62.4	62.6	166	14.8	6.6	6.2	221

*Includes 18 fruits and berries.

Source: *Consumption of Agricultural Products*, Bureau of Agricultural Economics, U. S. Department of Agriculture (mimeograph), Washington, D. C., March, 1941, p. 11.

five years from 1909 to 1913 to an average of 50.3 pounds for the five-year period 1935–1939—an increase of 169 per cent. Whereas the per capita consumption between 1909 and 1939 of all fresh fruits other than apples and citrus fruits remained relatively constant and the consumption of apples decreased, the demand for citrus fruits increased sufficiently so that the consumption of all fresh fruits remained relatively stable.

Increasing Competition from Local Apples

Although the total market for apples in the United States has been declining steadily since 1915, an even more important factor affecting the economic situation of the Washington apple grower has been increasing competition from apple producers of the East and Middle West. It has been noted previously that prior to 1930 the Washington producer overcame his handicap of distance from markets by putting up a better pack of fruit than did his local competitor. A Department of Agriculture bulletin in 1926 reported that eastern apple packs showed a lack of uniformity, that the product was not adequately graded, and that the same grade term often included a wide range of quality and condition.

The gradual decline of the apple industry since 1915 has slowly but surely forced eastern and middle western growers to pay more attention to pack, condition, and color. This was true especially during the decade of the 1930's when prices generally were low. A. W. McKay reported in 1938 that eastern and middle western growers were paying more attention to thinning, spraying, and other practices which improve quality and appearance and that grading and packing had been much improved.

This improvement, together with a greater emphasis on price on the part of the consumer, led to a substantial loss of volume for the Washington grower in those eastern markets which are subject to a large amount of competition from local apples. This local competition is greatest in the area east of the Mississippi River and north of the Ohio River. And this is the area which contains the largest part of the population of the country and which constitutes a substantial portion of the total nation-wide market. Car-lot unload data indicate a substantial drop in the consumption of Washington apples throughout this area. The general trend is well exemplified by the substantial decline that has taken place in New York and Chicago, the two largest markets for Washington apples prior to 1941 (Table V). The decline in unloads for New York since the early 1930's has been over 50 per cent, whereas the decline for Chicago has been 35 per cent or more. And it seems significant that no reversal of this trend has taken place even during the present period of expanded wartime markets.

Accurate unload information for eastern apples is not available because of incomplete coverage of truck receipts, but there is little doubt that the decline has been much greater for western than for eastern apples. McKay states that receipts of apples at New York in 1929 were composed of 49 per cent western and 51 per cent eastern but that this had changed by 1937 to 37 per cent western and 63 per cent eastern.

TABLE V

CAR-LOT UNLOADS OF WASHINGTON APPLES IN SELECTED CITIES, 1928–1943

Calendar Year	*New York*	*Chicago*	*Los Angeles*	*Five Selected Southern and Southwestern Cities**
1928	4,857	3,335	638	1,045
1929	3,899	1,955	433	925
1930	4,227	3,025	769	1,168
1931	4,912	2,674	900	1,094
1932	3,801	2,137	1,342	946
1933	3,127	2,061	1,430	1,011
1934	2,913	2,272	983	1,216
1935	2,572	2,119	1,082	1,262
1936	2,151	2,129	1,412	1,500
1937	2,103	2,015	1,251	1,135
1938	2,071	1,899	1,333	1,393
1939	2,141	1,870	1,135	1,418
1940	1,851	1,693	1,617	1,450
1941	1,847	1,740	1,791	1,366
1942	1,812	1,689	2,118	1,540
1943	1,310	1,757	1,565	1,468

*Atlanta, Dallas, Ft. Worth, New Orleans, Oklahoma City.

Source: Annual car-lot unload reports of the U. S. Department of Agriculture for selected fruits and vegetables.

With the loss of the highly competitive eastern and middle western markets, the Washington apple grower has turned to areas in which the competition from local apples is less severe. Los Angeles, once a relatively unimportant market in comparison with New York and Chicago, has more than doubled its consumption of Washington apples within the past 15 years (Table V). In 1942, unloads in Los Angeles exceeded those of both New York and Chicago. There have been other factors in the Los Angeles situation, besides the lack of strong competition from high-grade local apples, that have been partially responsible for the development of this market. These include a rapidly expanding population and an unusually favorable opportunity for two-way truck transportation in which citrus fruits move northward and apples southward.

Nevertheless, the fact that absence of local competition has been a most important factor during recent years in the selection of markets for Washington apples is shown by the increases in consumption that have taken place in the South and Southwest. Data for five cities located in these two areas show an average increase in the unloads of Washington apples of between 35 and 40 per cent between the period 1928–1932 and the period 1939–1943. Since the early 1930's, the market for Washington apples has been in the process of shifting from the region east of the Mississippi River and north of the Ohio River to the areas south of the Ohio and west of the Mississippi. And the most fundamental factor leading to this shift has been the necessity of avoiding areas with a substantial local production of apples.

EFFECTS OF THE WAR

The foregoing discussion has been concerned primarily with the economic situation of the Washington apple industry during the decade of the 1930's. The advent of war has brought many changes.

In the first place, costs of production have increased. Materials and equipment have risen in price to some extent. Many items have been in short supply and difficult, if not impossible, to obtain. This has resulted in higher costs because of the necessity of using inferior substitute items or none at all. But the principal increased cost has been that for labor. Hourly wage rates increased from $.25 in 1939 and 1940 to an estimated $.75 in 1943. Even at this higher wage rate, labor has been more difficult to obtain and much less productive than it was before the war. One estimate has placed the decrease of labor efficiency between 1940 and 1943 at about 15 per cent. The decline was probably greater in 1944.

Nevertheless, the industry has been relatively prosperous during the war period since prices have increased faster than total costs. One study indicates an increase in costs of approximately 100 per cent between 1940 and 1943, but prices increased during this period by 250 per cent. In 1940, the average net-to-grower price for Washington apples, as computed by the Bureau of Agricultural Economics, was $.78 per bushel. The corresponding price amounted to $1.14 per bushel in 1941, $1.91 in 1942, and an estimated (preliminary) $2.72 in 1943.

Selling has not been a problem during the war period. The armed forces and Lend-Lease have purchased substantial quantities of apples. High consumer incomes and shortages of other food items have resulted in the maintenance of a high level of civilian demand. The commercial export market has been virtually eliminated because of shipping shortages, but this has never been a

very important factor in any case. Because of the shipping shortage, Canadian apples normally exported overseas have entered the United States, but there has been sufficient room for everyone. The principal problem has been to find the apples required to fill all orders. As a result, sellers have taken advantage of the situation to eliminate, at least in part, the more expensive packs. Less attention has been paid to the maintenance of high quality and good condition. Although there is good argument for the elimination of frills during wartime, there can be little excuse for actually lowering the quality of the product. Whether permanent damage has been done to the reputation for quality usually maintained by Washington apple growers remains to be seen.

POSTWAR OUTLOOK

Postwar prospects for the Washington apple industry actually are not so unfavorable as might be implied from the analysis of economic trends during the 1930's. There are several favorable factors in the picture although much depends upon the level of consumer incomes and the degree of general business prosperity during the postwar period.

In the first place, the Washington grower will enter the postwar years in much better financial condition than at any time in the past 15 or 20 years. As a result of wartime prosperity, much indebtedness has been retired and many growers have accumulated a backlog of savings. Wartime profits have been used to build up equipment, to intensify efforts to control the insect population, and to apply large quantities of fertilizer. Many orchards will be in position after the war to produce apples more economically than ever before. On the other hand, some growers have wasted funds and have not received satisfactory value for money expended. In such cases, it may not be possible to earn a satisfactory return upon the capital invested.

Secondly, the quantity of apples produced annually during the next 10 to 15 years will be less than the quantity produced during the 1930's. The pulling of trees and the failure to replant, already described, will mean low production levels for the United States as a whole and especially for Washington. Thus the supply of apples should be in such relationship to demand that higher prices will be realized than were obtained before the war. Large surpluses which tend to reduce prices below costs of production will probably be avoided, at least for a number of years.

Thirdly, there is some reason to believe that the general level of business activity will be relatively high for several years after the war. The large accumulated demand for industrial equipment and consumers' durable goods, plus a considerable backlog of corporate and individual savings, should keep employment and consumer incomes above prewar levels for a number of

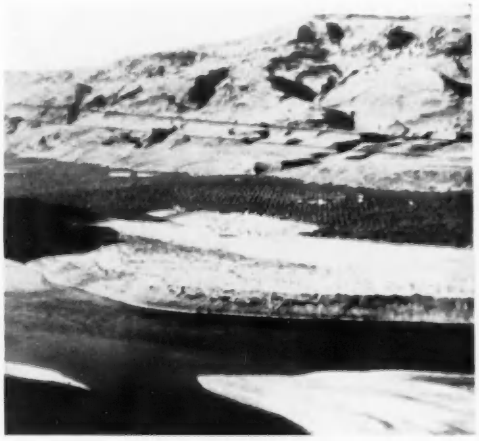

FIGURE 2.—Typical orchard site. Terrace on Columbia River near Chelan. Note the orchards stretching along terrace and the pickers' cabins near the center.

years. Business and governmental agencies are both engaged in active planning for maximum employment and production during the postwar period. On the other hand, wartime necessity has proved our really tremendous productive capacity, and there is always the possibility that this backlog of demand can be reduced more rapidly than would now seem feasible. It is not within the scope of this analysis to forecast postwar business conditions, but it is important to point out that the economic prosperity of the Washington apple grower during the immediate postwar years will be dependent primarily upon the degree of general business prosperity.

The above discussion of favorable factors should not be interpreted to imply that the Washington apple producer need have no care for the future. These favorable factors are essentially short-run considerations covering the next five or ten years. Furthermore, they are based upon the fact that the Washington apple industry is already operating and will continue for several years to operate at levels substantially below those of the late 1920's and early 1930's. In the long run, can the industry avoid further contraction or even perhaps retrieve some of the ground that has already been lost?

The answer to this question depends, of course, upon certain long-run aspects of the competitive situation. If competing apple areas (and it should be realized that apples are grown in commercial quantities in 38 of the 48 states) are able to produce and place on the market a product of comparable quality at a lower total cost, it is likely that the Washington industry faces a period of further contraction. The fact that prices have been high during the war and that they may be satisfactory for several years after the war would merely result in expanded production in the competitive areas. Actually, the difficulties of adjustment might be even greater because the Washington industry would probably be encouraged to expand because of these same high prices.

Furthermore, there is no definite evidence that the declining consumption trend for apples has been permanently reversed. The large wartime demand probably has been stimulated in part by shortages of other fruits. Postwar competition from citrus fruits, canned and dried fruits, and fruit juices will be at least as great as it was before the war. High consumer incomes and high price levels are as likely to encourage the production of these competitive fruits as they are to stimulate the production of apples. Thus the Washington apple industry in the long run would face the same problems that existed during the decade of the 1930's.

Obviously, the permanent solution to the Washington apple problem lies in eliminating the competitive disadvantage under which it has operated for a decade or more. Costs must be reduced where possible in order that every advantage be obtained. But it is unlikely, because of the long transportation haul, that costs can be reduced sufficiently to compete on an equal basis with local apples. Therefore, it is most important that production and marketing practices be improved in order to attain the greatest efficiency of operation and to present to the consumer a high quality product which will command a premium price. Only by the taking of forward-looking measures will the industry overcome its competitive handicap and emerge in a sound economic position.

ATTEMPTS AT SOLUTION OF THE PROBLEM

Leaders of the Washington apple industry, in fact, have long recognized

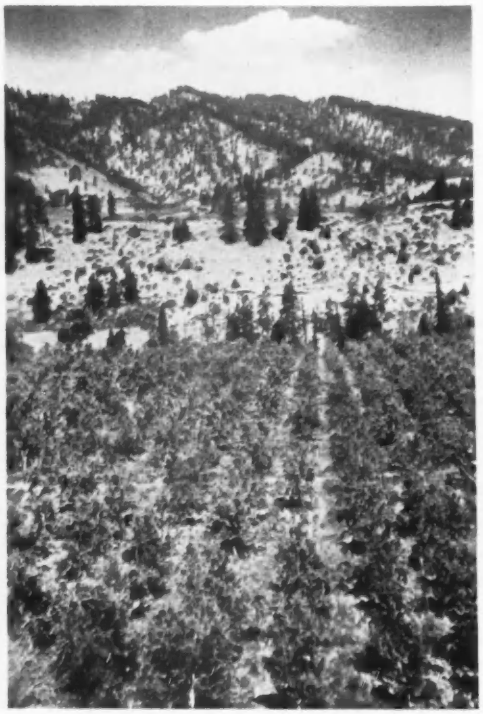

FIGURE 3.—Scene in the Wenatchee Valley Subarea. Looking across narrow Wenatchee River Valley. Apple orchards on low terrace.

its vulnerable competitive position, and many attempts have been made to improve the situation. From time to time for more than 30 years, various groups have tried to promote interest among growers and dealers in agencies and plans which would assure greater coöperative action on the part of all factors. Improvements in marketing received paramount consideration because distribution of the product from the producer to the consumer constituted the main problem of the industry. Thus, prior to 1940, the principal proposals for aiding the competitive position of the Washington grower revolved around (1) the organization of some type of coördinated sales agency, and (2) the institution of an industry advertising program.

Coordinated Sales Agency

Efforts to establish a coördinated sales agency involved two principal types of organization. In the first type, it was proposed that a coöperative organization be established similar in purpose, scope, and form to the California Fruit Growers Exchange. Existing coöperative groups would have become local members of a federated coöperative, and new local groups would have been formed in districts in which no coöperative existed. The federation would have had control over pricing policies, grading and inspection of fruit, orderly movement of the product to market, and other sales policies. Such an organization could have accomplished a great deal toward general improvement of the marketing process, which might well have resulted in higher prices to the grower and a greater demand for the product.

In the second type of organization proposed from time to time, a clearing house would have been established to make available to growers and shippers information on sales, shipments, and prices. This is a much looser type of organization than the coöperative and does not control directly the marketing of the product. Its adherents claim, however, that shippers should be able to control the distribution of the product individually since relatively complete information on market conditions is available. Obviously, any such control must be less effective than that obtained by a coöperative if for no other reason than the fact that different people draw different conclusions from the same information. Furthermore, any attempt of the several members of the clearing house to work together too closely in fixing prices might result in a violation of antitrust laws.

The various attempts to organize a coördinated sales agency were not particularly successful. At the present time, there are four principal coöpera-

tives engaged in the marketing of Washington apples, but none of these has attained any substantial degree of control over the industry. All four of the organizations together handle only some 25 to 30 per cent of the Washington apple volume. The formation of clearing-house associations likewise met with little success prior to the late 1930's. Shippers in both Yakima and Wenatchee organized in 1939 into closely-knit groups in an effort to obtain some of the advantages of coördinated marketing. These organizations are still in existence and might be assumed to have attained a permanent status. The recorded history of such groups, however, shows that their strength cannot be gauged during a period of prosperity and rising prices but only during a period of rapidly falling prices. In any event, a shippers' association does not necessarily provide the solution to the growers' problems.

Advertising

Sporadic efforts to organize and finance a consistent advertising program for Washington apples finally culminated in 1937 with the passage of a state law levying a compulsory advertising assessment. Funds are collected by assessing the growers $.02 per 100 pounds ($.03 since August 10, 1942) on apples shipped for consumption as fresh fruit. The advertising program is supervised by a commission of growers and dealers, which spent on advertising and other sales-promotional activities an average of $180,000 per year between 1937 and 1942. Available funds since 1942 have been greater but expenditures have not increased, and surplus funds are being set aside for the postwar years.

The success of this advertising program has been discussed elsewhere at some length by one of the present writers, and it need not be repeated here. Advertising probably has been somewhat effective in creating demand for Washington apples. But, obviously, it does not constitute the solution to the Washington apple problem. More fundamental factors are involved, and advertising in itself is hardly capable of reversing an economic trend. Furthermore, to obtain the maximum effect, advertising should be coördinated with other sales policies. This can be done only by organizing a marketing coöperative which has control over the selling and advertising of the major portion of the Washington apple crop.

FIGURE 4.—Scene in the Wenatchee Valley Subarea. Looking down the valley with the city of Cashmere in the background. Note the apple orchards on the heights above the city.

Land-Use Planning

The most recent attempt to rehabilitate the Washington apple industry was begun in 1940 and was a much more inclusive program than any previously devised except that it applied only to the Wenatchee-Okanogan region. This area, which specializes more completely in apples than does the Yakima region, was declared to be a distressed agricultural area by the federal government, and a complete survey of its problems was made by the Department of Agriculture. After a considerable amount of study, the Regional Agricultural Credit Corporation, a federal government financing agency of the early 1930's, was reopened to furnish

credit facilities until the growers could organize plans for their own rehabilitation.

The problem was then turned over to local Land-Use Planning Committees composed entirely of growers. These committees were organized on a "community" basis. The three counties composing the distressed area—Chelan, Douglas, and Okanogan—were divided into some 22 communities. Growers in each community elected representatives to a local Land-Use Planning Committee. From these local committees, members were elected to county and district committees. As implied in the name, the primary function of the committees was planning. They could establish general programs, but they did not have direct authority to enforce coöperation from growers.

These committees, then, with the aid and advice of representatives of the federal government and of state agricultural extension agents, worked out long-range programs for the reorganization of the industry. Plans included every phase of the apple industry—production, marketing, orchard rehabilitation, financing, debt adjustment, the purchase of supplies, and many others.

Space does not permit a detailed discussion of the various reorganization programs. Coöperative methods of purchasing supplies were adopted, and many suggestions were made for orchard rehabilitation and improvement of production practices. Perhaps the most far-reaching development was the organization of the Washington Growers Clearing House Association with authority to enter into contracts with growers, marketers, and warehousemen. These contracts provide that all those signing the agreement will abide by the rules of the Clearing House Association in the sale of the product. The Association has a great deal of authority over prices, quality and condition, time of sale, and similar matters, but very little of it has actually been exercised to date.

FIGURE 5.—View in the Upper Yakima Subarea. Looking eastward across narrow Naches Valley at Selah Heights. Note apple orchards on this plateau which is one of the two leading apple districts of the Yakima Area. Frost and water drainage are best on the uplands.

The principal weakness of this comprehensive planning effort was the lack of authority to compel adoption of the suggestions of the Land-Use Committees. The Regional Agricultural Credit Corporation, of course, could bring some pressure to bear upon those growers to whom it was extending credit and in whom it had a direct financial interest. A considerable amount of coöperation has been obtained in this and other ways. But it is difficult to evaluate the potential success of this overall planning attempt because of the improvement of business conditions which followed im-

mediately after its inauguration. In other words, the Washington grower's financial position has improved greatly, and much of the early enthusiasm for rehabilitation has been lost. The Land-Use Planning Committees are still functioning in the Wenatchee-Okanogan area, but they have not yet spread to the Yakima area as was originally hoped. It is said that interest even in the Wenatchee region is at low ebb at the present time.

CONCLUDING OBSERVATIONS

Much of the Washington apple problem could be solved if production and marketing costs could be lowered sufficiently to allow Washington apples to compete to better advantage with eastern and middle western apples. Some reductions in production costs can probably be made, but they are not very great. The United States Department of Agriculture, in its survey of the Wenatchee situation, came to the conclusion that production costs per acre could not be reduced appreciably. Only two possible ways of reducing production costs were suggested: (1) the coöperative purchasing of supplies, and (2) the possibility of reduced land taxes and irrigation-water costs if orchards were revalued in light of their worth at that time. It was thought that packing and washing costs might be decreased somewhat as a result of the lowering of spray residue requirements, which became effective in 1941. The total saving through these three items was estimated at possibly $.05 or $.06 per box.

FIGURE 6.—View in the Upper Yakima Valley Subarea. Looking north across the Naches Valley, with Clemen Mountain in background. Pear orchards in foreground. Soft fruits are frequently grown in valley bottoms.

It was believed, however, that production costs per box might be decreased by increasing yields per acre. There are indications that the yield of Washington apples per acre has been decreasing in recent years. Better fertilization and better control of insect pests might increase yield sufficiently to decrease costs per box even though costs per acre were increased. Furthermore, it was suggested that the immediate withdrawal from production of poorly located and inefficient orchards would decrease the present average cost of Washington apples and would be beneficial in stabilizing the industry.

It is also possible that marketing costs of the industry might be reduced through the organization of a producer's coöperative. Under the present marketing system, selling costs alone amount to $.10 per packed box in normal times. There is no way to estimate accurately the potential saving from a coöperative. It would depend upon the strength and efficiency of the coöperative, but it seems likely that some saving could be made by such an agency because of the large volume that would be handled. The presence of so many small shippers, some 150 in the Wenatchee area alone, has probably not resulted in the lowest possible selling costs. Packing expenses might also be reduced by a coöperative in the same way.

In addition to reducing costs, the program for the solution of the Washington apple problem should include steps to increase returns to the grower. The principal method of approach to this phase of the program lies again

in the organization of a producers' marketing coöperative. Such a cooperative would have the facilities and the authority to control the quality and condition of all fruit sold. It would have sufficient market information to regulate the time of shipment and the markets to which shipment should be made, in order that the best available price might be obtained. It would be able to employ sales agents in major markets who would promote the sale of the fruit, find new outlets, and report on prices and market conditions. Finally, it would be able to coördinate the present advertising program with other sales policies.

Such a coöperative, to be effective, would require a membership of such size that it would be able to control the sale of, say, 75 per cent of the total production of Washington apples. Many attempts have been made to organize a dominant coöperative. Some leaders of the apple industry hope that the present Washington Growers Clearing House Association may provide the nucleus for such an organization. But the present period of prosperity has eliminated the immediate incentive for drastic reorganization. Furthermore, any comprehensive change such as that suggested would eliminate existing marketing agencies and completely revolutionize the present marketing structure. Therefore, it is not likely that a dominant coöperative will be organized, at least for many years.

THE GROWTH OF BRISTOL

Henry Rees

THE construction of a growth map is a convenient method of summarizing the expansion of an urban area: it shows the way in which the forces of expansion have been controlled and canalized by the physical environment. The interpretation of such a map therefore requires some knowledge of the physical framework of the area; hence the reproduction here of a physical and a geological map.

The former is based upon the 1-inch Popular Edition of the Ordnance Survey, Special District Sheet of Bristol, published in 1922. Unfortunately that map does not show contours in the built-up areas, and the approximate position of these has been inserted by reduction from the 6-inch map. The drainage indicated in the city area is not the present artificial system, but that which so far as can be ascertained existed at the time of the foundation of the settlement.

The geological map is based on that published by the Geology Survey in 1872. This is a rather rare hand colored map, and, it is to be feared, somewhat out of date; but a more modern color printed map has still to appear.

From the geological point of view the region is one of considerable complexity. A glance at the map reveals the unusual variety of the deposits for such a small area. We are here concerned mainly with the surface deposits. Most dominant is the Trias, which forms the nucleus of Bristol and stretches northwestward to link this area with the Midlands; it forms also a terrace overlooking the Alluvium of the Severn estuary. The deposit gives rise to areas of moderate elevation and is suitable to settlement. As is often found elsewhere in Britain, the Trias in parts overlaps the Coal Measures; thus the economic limit for working coal in this region has been placed as far west as the center of Bristol.

The Coal Measures consist of an upper and a lower division, of which the lower is generally the more valuable, separated by the barren Pennant Grits; the latter have supplied stone for many of the modern buildings of Bristol. The Coal Measures, like the Trias, form areas of moderate relief which were formerly forested, but patches of oak woodland are all that remain of the Forest of Kingswood.

The Millstone Grit outcrop is of such small extent that it had little effect on the settlement of the region. It is, however, responsible for the existence near the center of Bristol of Brandon Hill, whose steepness has preserved it from the encroachment of nineteenth century building; it is now a public park and crowned by the monument to Cabot.

The exposures of Carboniferous Limestone have had a marked repellent effect on settlement. The main mass takes the form of a ridge aligned northeast and southwest and it is through this that the Avon has cut its famous gorge below Bristol, with the result that the largest vessels must dock at Avonmouth. The limestone forms the highest areas of the region, rising to 500 feet in the southwest with a marked escarpment facing east and southeast. It gives

rise to rolling downland, woodland, and heath, and everywhere surface drainage is lacking.

Adjoining the main exposure of Carboniferous Limestone extends a belt of Old Red Sandstone, the oldest formation of the region. Its surface is slightly lower than that of the limestone, and it is less porous. Though it exercises little attraction for settlement, dwellings have spread to it in late years, for example in the area southwest of Westbury.

The Lias consists mainly of clay and forms areas of subdued relief which near Bristol are quite suitable for settlement. Separating this formation from the underlying Trias are narrow exposures of what are known as the Penarth Beds, classed as Rhaetic; they frequently give rise to steep escarpments which have had some effect on the settlement pattern. It remains to notice the Alluvium, which, as in most other ports, normally repels domestic settlement but attracts industry. Since for most of their courses the streams are deeply incised the Alluvium is limited in extent except in the immediate neighborhood of the city and along the Severn coast. This last area has been chosen as the site for the modern deep water docks.

The method of constructing a growth map by superimposing the successive additions in area from an historical sequence of maps on a uniform scale has been elaborated in an earlier study

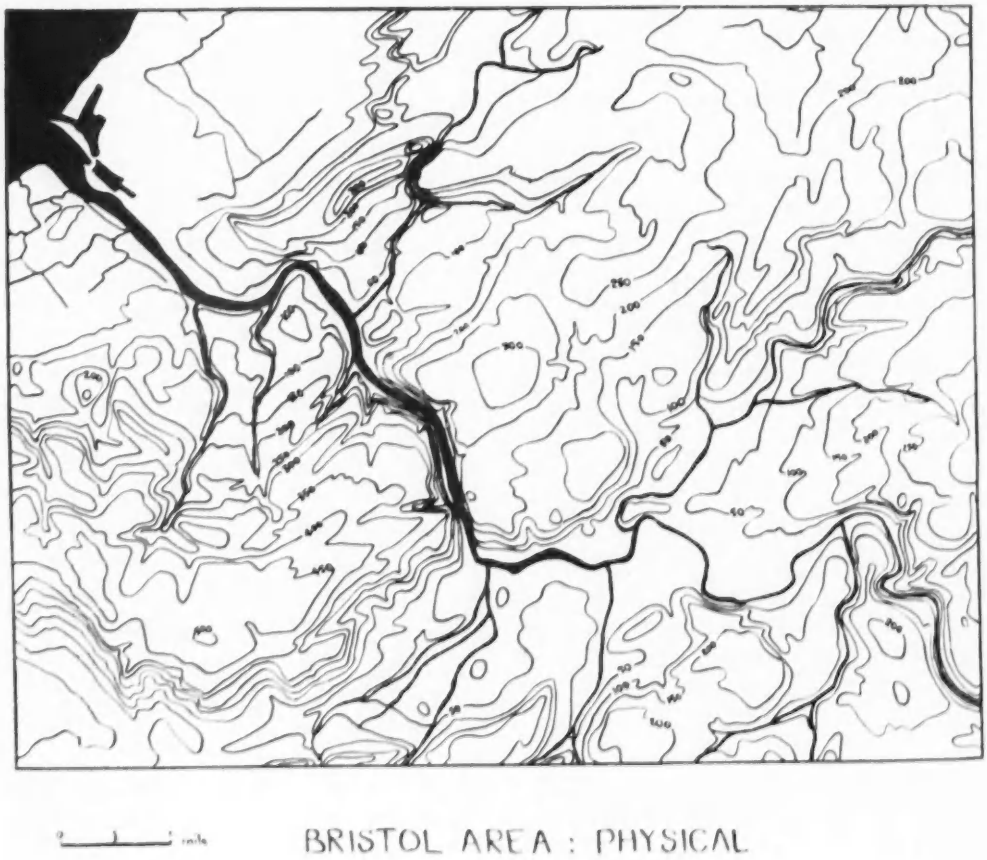

FIGURE 1.—Physical area of Bristol.

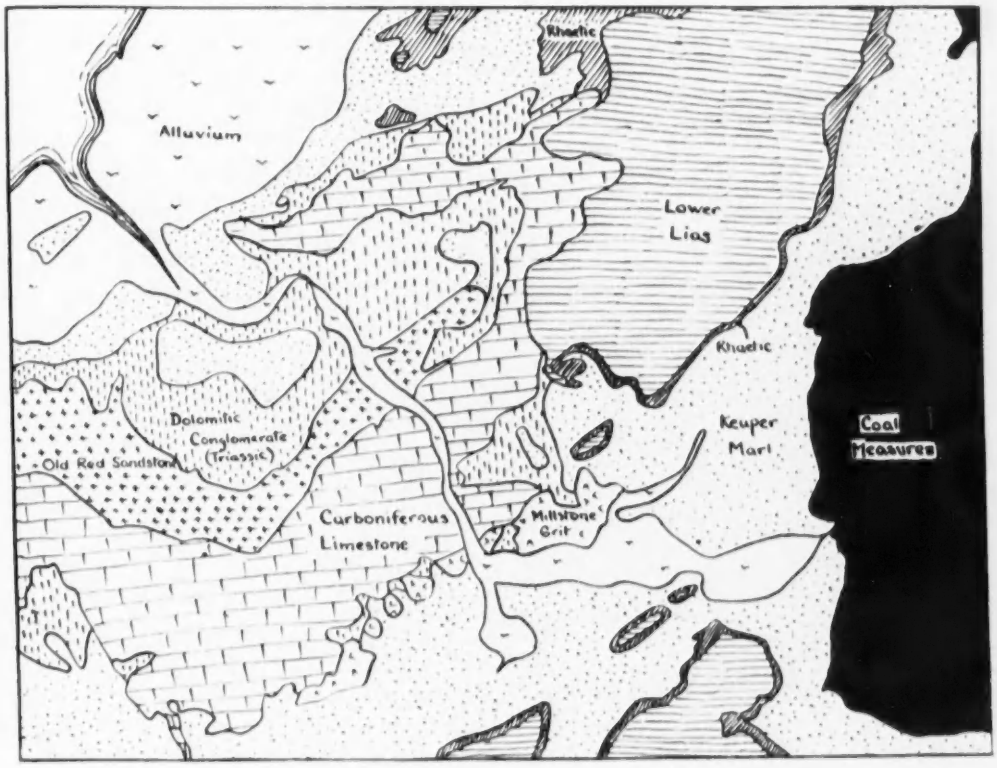

FIGURE 2.—Geology of the Bristol Area.

("A Growth Map for North East London") and with a warning that the successive periods rapidly diminish in length we may proceed immediately to an interpretation of the expansion during each period.

DEVELOPMENT BEFORE 1581

The nucleus of the city was a hill of Keuper Marl reaching 50 feet situated in the peninsula at the junction of the Frome and the Avon. The hill was fortified by a Saxon wall and in Norman times by a castle. Hoefnagel's plan shows that by 1581 Bristol had become sufficiently prosperous as a port and manufacturing center to require 14 churches; the original walls had been extended to include some of the marshland between the Frome-Avon junction and land south of the Avon. The built-up area was still almost entirely confined by the Mediaeval walls. Today this central area is the financial and commercial quarter; its narrow streets largely correspond in their layout with that imposed by the walls in Mediaeval times. It should be noted that Hoefnagel's plan covers only the area occupied by the Bristol of his day. There is no map of a corresponding date and of a scale sufficiently large to be used for the rest of the area. Saxton's county maps of 1575 and Speed's of 1610 named all the outlying villages but gave no indication of their sizes; it has therefore not been possible to indicate the growth of outlying settlements before 1581.

DEVELOPMENT 1581–1830

During the 250 years which ended with the publication of the First Edition of the Ordnance Survey 1-inch map, expansion was slow by modern standards. That period had seen many changes in the activities of Bristol. Her merchants had begun by patronizing the discovery and colonization of trans-Atlantic lands and had continued by building up a considerable commerce with them which was maintained after the Declaration of Independence. The notorious slave trade had grown, prospered and declined, and had by 1830 become extinct. The woolen industry was struggling for survival against its new rivals in the West Riding based on water power and steam. In spite of setbacks in commerce and industry a monumental scheme of dock development had been carried through by 1809, namely, the converting of nearly two miles of the Avon into a wet dock (the Floating Harbor) and the diversion of the surplus water into an artificial channel (the New Cut). The period saw in addition the first systematic attention paid to road improvement since Roman times. Turnpike Trusts which had been set up by 1830 were inefficient and costly, but it is generally agreed that considerable improvement of road surfaces was effected. With

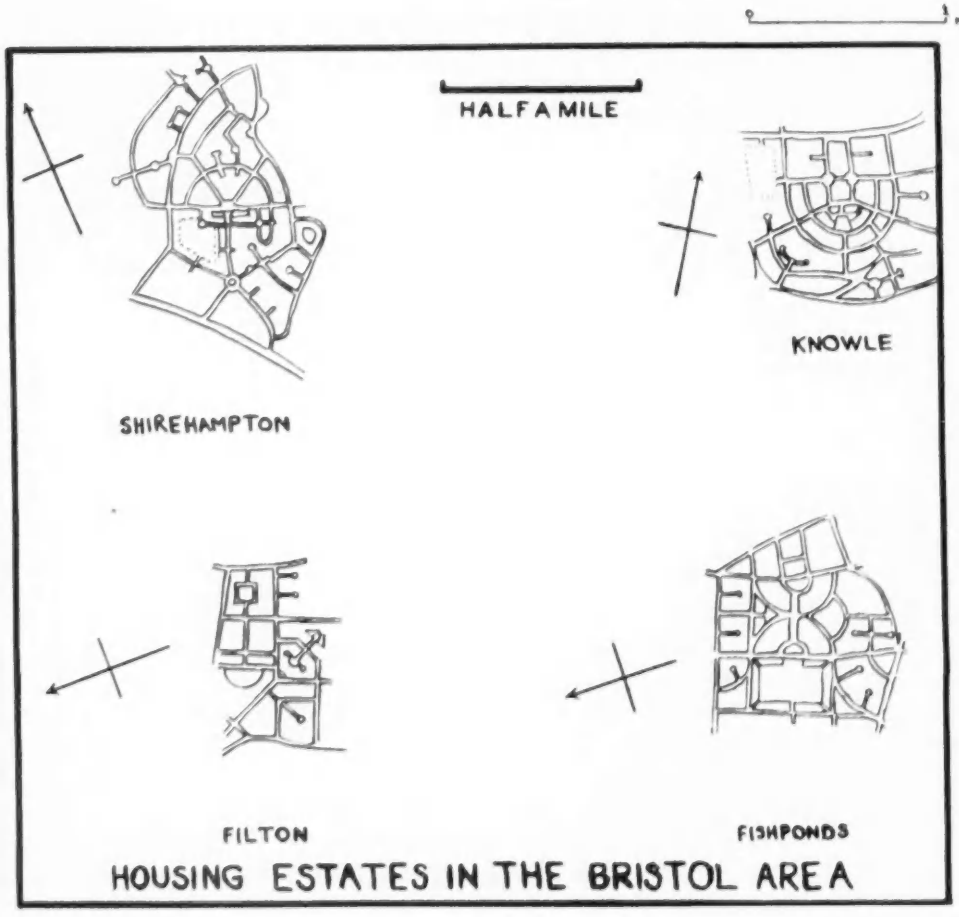

FIGURE 3.—Housing Estates in the Bristol Area.

very few exceptions the modern radial roads have sprung from the nineteenth century turnpike system.

During this period the city expanded in all directions. In the absence of natural barriers it was in general limited to the south by the artificial water barrier of the New Cut. Land between the Floating Harbor and the New Cut provided suitable accommodation for the industry of the port, and though much of the area has been reconstructed and more fully occupied, it is still industrial in character, with timber yards, railway sidings, and the cattle market.

To the southwest extended a ribbon of development along the turnpike road towards Bedminster. In the angle between the Frome and Avon, settlement had extended beyond the wall to occupy almost the whole of the marsh. In this area most of Queen Square had been completed by 1717 and 240 trees planted. Many other new formal streets and about a dozen squares were laid out during the period, for Bristol had become a center not only for commerce but also for recreation and culture. In the district to the north, known as Kingsdown, many long streets of tidy terrace houses were built in spite of considerable topographic difficulty (some of the short connecting streets leading southwest descend in steps).

To the west the development of Clifton had begun by the erection of large well-to-do houses beyond the 200-foot contour—the first penetration of building on Carboniferous Limestone subsoil. Filton and Westbury-upon-Trym in the north were nucleated rural villages linked by turnpike roads to Bristol but as yet untouched by the expanding city.

Settlement eastward was much more patchy, with a notable growth of main road ribbon development, for example in Fishponds and St. George. This, the region of the exposed coalfield, is today very mixed in its surface features. It was formerly an area of natural woodland—the Forest of Kingswood—though little remains today except for a more than average number of commons. The present day meandering byroads originated as forest paths. The modern 6-inch Ordnance Survey map shows how the land has been divided into small fields of pasture for milch cows together with a considerable development of orchards to supply the Bristol market. More significant is the presence of several collieries and a dozen quarries or groups of quarries in this area, working clays of the coal measures. In addition large areas are occupied by industrial works. It is not suggested that all these features of the landscape were present in 1830; many of them had certainly arrived by 1880, as the first edition of the 6-inch map makes clear; they do, however, illustrate the direction in which the area has been moving and help to explain the patchy development of this eastern region.

DEVELOPMENT 1830–1885

During this period the full effects of the harbor reconstruction were felt, with a consequent rise in the commerce of the port. The construction of railways had increased the importance of Bristol as a market center and a regional capital. Owing to the increasing size of vessels the Floating Harbor was of insufficient depth for the largest ships and towards the end of the period (1877 and 1879) new docks were constructed in the alluvial flats below the gorge at Avonmouth and Portishead.

The map shows the remarkable increase in the size of the city, mainly north of the Avon, where gradients were easier. The greatest expansion was in the Clifton district, to the west, where new terraces, crescents, and squares were laid out on the Triassic upland

stretching to the edges of Clifton and Durdham Downs. These, being of Carboniferous Limestone and over 300 feet high, were not eminently suitable to settlement but no doubt would by now have been swamped by the flood of housing had they not been acquired for the purpose of public open spaces by

dustry had continued to become concentrated on the alluvial flats of the Avon, where wide areas were occupied by railway sidings and warehouses, glue works, chemical works, gas works, and tanneries; hence the ribbon of settlement following the Avon upstream south of St. George.

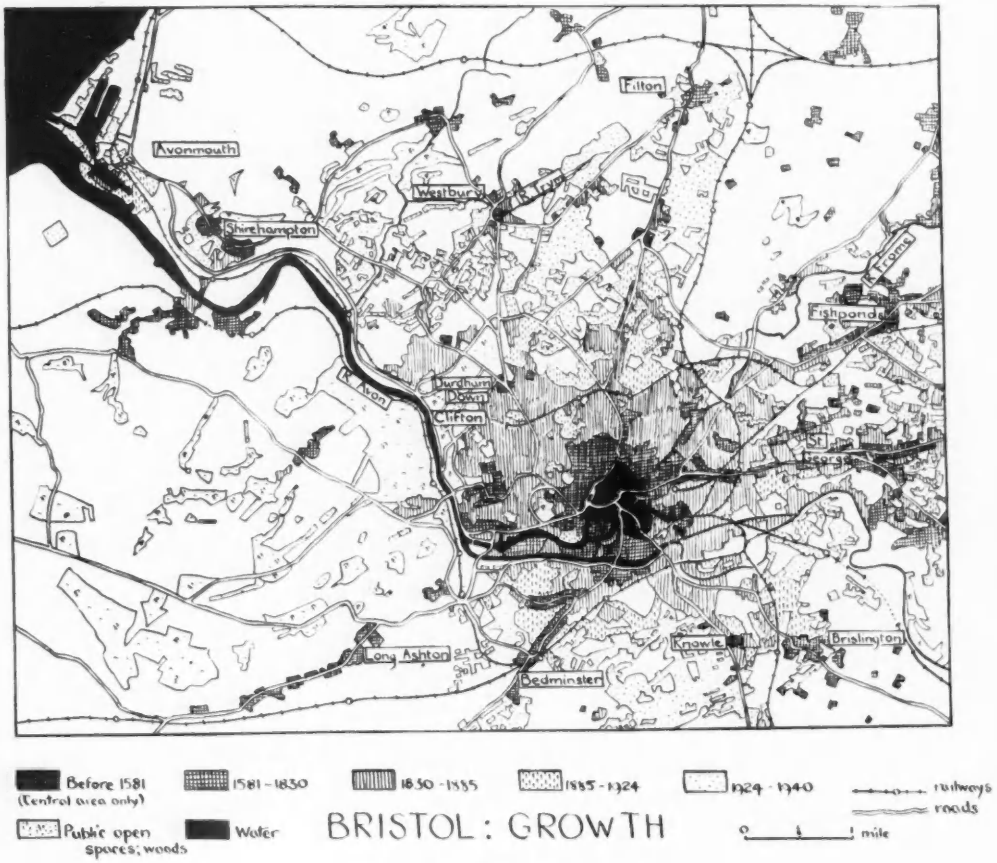

FIGURE 4.—Growth of Bristol.

the Corporation and the Society of Merchant Venturers. Beyond the Downs there arose in Sneyd Park an area of low density settlement, characterized by large houses standing in their own grounds.

In decided contrast were the rows of small houses which had sprung up in the northeastern quadrant and along the road to Filton in the north. In-

DEVELOPMENT 1885–1924

By 1885 the railway system of the Bristol area was complete and the progress of later expansion was no doubt related to the existence of cheap rail transport to the inner districts of the city. During this period important developments took place at Avonmouth. Warehouses were built surrounding the

Avonmouth Dock and an oil storage depôt had arisen. The ribbon development stretching towards Filton had broadened to form a wide tongue of settlement. It included some semi-detached houses but for the most part consisted of straight and uninspiring rows of terrace dwellings. Few new developments had taken place in the Fishponds and St. George districts, but in the south there was a notable extension of building to occupy the foothills of Trias which rise to 50 feet and form a comparatively flat bench overlooking the river. Thus the areas north of Bedminster and Brislington were occupied by rows of terrace houses standing in violent contrast to the old Saxon village centers.

DEVELOPMENT 1924–1942

This period saw the completion of the second of the Avonmouth docks—the Royal Edward, with its special accommodation for petroleum and grain. In common with similar developments on the fringes of London and other large cities, domestic building of the post-war period in Bristol has often taken the form of the "garden city" estate, with attractive street plans normally including numbers of culs de sac free from the bustle of through traffic. This applies to developments in the Fishponds, Knowle, Bedminster, and Shirehampton areas and in the district south of Filton.

Expansion took place in nearly every direction and was limited only by unusually difficult topography. Thus the Carboniferous Limestone area to the southwest was completely free from new building, its southeast facing scarp presenting a gradient of about one in seven. Difficulty of water supply would have made development difficult, but in any case much of it, as in Durdham and Clifton Downs to the north, has been reserved as a public open space. In the same way an area of difficult topography in the angle made by the Frome and its northern tributary (Figure 1), related to the narrow Rhaetic exposure, has been avoided by housing. It is to be noted that this area has been scheduled as a public open space and semi-residential neighborhood in the Bristol Development Plan (1930).

A remarkable concentration of post-war housing will be observed on the exposures of Lower Lias. These beds give rise to relatively elevated tracts which, though they have steep edges formed along the outcrop of the Rhaetic beds yet are areas of smooth topography, a valuable advantage in the construction of drainage and water supply systems. The limits of the new estates south of Knowle and Bedminster show a marked tendency to correspond with the boundaries of the Lower Lias. In the north the position is less simple: development has occurred both on the Old Red Sandstone and the Trias in addition to the Lias. There is a marked avoidance of the Carboniferous Limestone with its scanty water supply. Other areas have been avoided on account of difficult gradients; thus Shirehampton has grown southwards and westwards away from the limestone scarp overlooking it.

A growth map has a value shared by few other types. Not only does it serve as a reminder that the present form of a city is the result of a long historical development; in addition it shows precisely how in one small area Man's ambitions have been limited by the nature of his physical environment.

IRON IN THE ADIRONDACKS

Sven A. Anderson and Augustus Jones

FOR years American iron and steel industry has received approximately 85 per cent of its ores from the Lake Superior district, of which most has been of sufficiently high iron content to be used directly without processing; but it is generally agreed that the direct-shipping ore of the Lake Superior district will be exhausted in less than a generation. In 1942 its exhaustion was expected even sooner, perhaps within a decade, since accelerated war demands would require shipment of 100,000,000 tons of ore per year. When such large shipments did not materialize, experts modified their estimates and now expect depletion in the 1960's.

Eventual exhaustion of direct-shipping ores will obviously not eliminate the Lake Superior district as an ore producer, but it will necessitate use of ore of lower iron content. In fact, iron content of the ore mined has declined steadily for many years, averaging 51.5 per cent in recent years, and there is every indication that the decline will continue. Some experts believe that ultimately 25 per cent ore will have to be used. Exploitation of lower grade ores will require ore concentration and beneficiation. Concentration of Lake Superior ores has been carried on since about 1910, and in recent years shipments of treated ores have reached a figure of more than 15,000,000 long tons per year. Very great increase in the shipments of treated ores seems inevitable in the next two or three decades. Such ore concentration, however, means increased costs, which in turn will reduce competitive advantage heretofore enjoyed by the Lake Superior region. Conversely, it will enhance competitive strength of other ore producing regions, notably the Adirondack district in New York, in which there is already much evidence that it will play an increasingly significant rôle in supplying iron ore to American industry in the future. At present five mining developments are active in the Adirondack region, namely, Mineville–Port Henry–Fisher Hill, Lyon Mountain, MacIntyre (Tahawus), Clifton Mines, and Benson Mines.

Geology of the Deposits

Magnetites of the Adirondacks are of two kinds: igneous and sedimentary. The igneous deposits, found only in limited areas, are high in titanium. The sedimentary ore deposits were probably originally iron carbonate, altered to magnetic iron oxides (Fe_3O_4). Chemical composition of the ores shows great variation, ranging from magnetite heavily intermixed with quartz, feldspar, and hornblende to nearly pure magnetite, some of it with an iron content of 60 to 70 per cent. On the basis of phosphorous content, it may be classified into low-phosphorous, Bessemer, and non-Bessemer grades. All three grades are produced in the Adirondack district. The bulk of non-phosphorous ore is produced by the Lyon Mountain mine, whereas Bessemer and non-Bessemer ore is obtained from the ore beds of the Mineville–Port Henry area. With few exceptions, the Adirondack magnetites cannot be used as direct-shipping

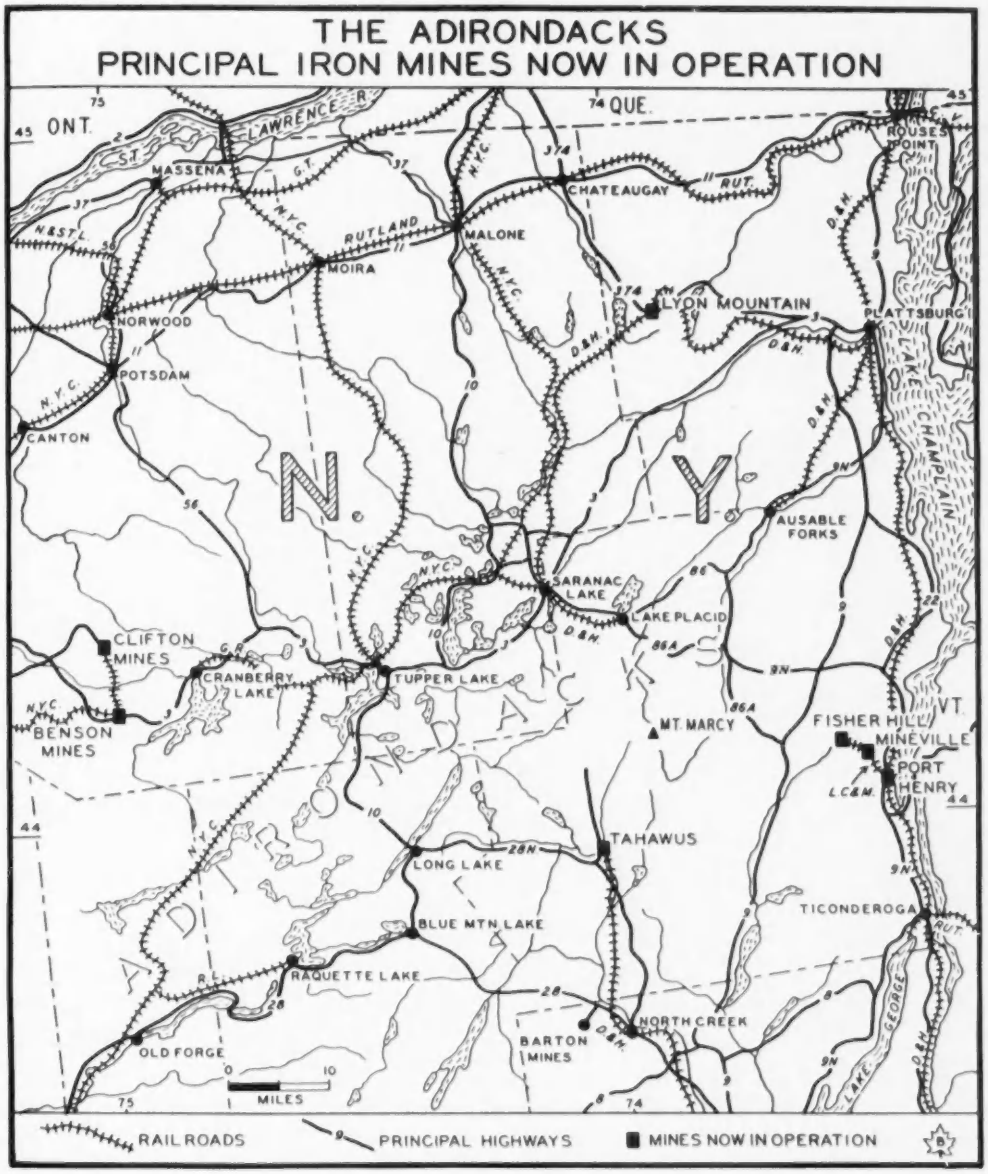

FIGURE 1.—Map of the principal iron mines in operation.

ores, though they readily lend themselves to processes of magnetic concentration and sintering. The iron content of sinter thus obtained ranges from 68 to 69 per cent, with an insignificant amount of moisture. In comparison, Minnesota and Michigan hematites contain only 50 to 55 per cent iron but 10 to 12 per cent moisture.

EXTENT AND IRON CONTENT OF THE RESERVES

The character of the geological formation and lack so far of modern scientific exploration, except in a relatively small portion of the region, preclude anything but mere guess as to extent of the ore reserves in the Adirondack

region. In 1935, the iron bearing territory of northern New York State, which covers approximately 12,000 square miles, was estimated to hold about 600 million tons of minable magnetite ore and two billion tons of titaniferous ore. An indication of the productiveness of the region may be obtained from a consideration of the yield from the Witherbee–Sherman properties, located near Port Henry on the shore of Lake Champlain. From 1870, when operations were first begun, to 1942, these mines produced approximately 31,000,000 tons, in spite of intermittent periods of suspension of operations. In 1943, the Adirondack region produced more than 3,000,000 long tons of crude ore, and in 1944 nearly 5,000,000 long tons, relatively high production attained despite severe labor shortage which seriously hampered operations. Production figures for recent years reflect in part accelerated war demands.

The iron content of the Adirondack ores varies from almost pure magnetite found in some of the Mineville openings down to the 22 or 25 per cent iron content currently the lower limit for profitable concentration. According to D. B. Gillies, vice president of the Republic Steel Corporation, average ore of the region would probably not exceed 35 per cent metallic iron, indicating that the typical ore is about half magnetite and half gangue by weight. Theoretically, pure magnetite contains 72.4 per cent iron. As a rule, the richest Adirondack ores are derived from deposits in the Mineville–Port Henry area, where considerable part of the output can be segregated into lump ore containing about 61 per cent iron, at least equal in quality to the lump ore of the Lake Superior region, and can be delivered at steel plants in Pittsburgh and the Mahoning Valley in competition with Mesabi ores. The major part of the Adirondack ore is processed; and when ground, concentrated and sintered, the product averages 68.5 per cent iron.

Concentration and Sintering

The processing of the ore is done in several stages. First the ore is sent through two or three crushing operations to permit elimination of as much rock (gangue) as possible. The ore is then concentrated magnetically to a 68 to 69 per cent iron content. Because of the grinding process necessary to obtain a high grade concentrate of the Adirondack magnetites, the resultant product is not desirable from a physical standpoint for use in either the blast furnace or the open hearth furnace. The concentrate is therefore fused into a porous mass called sinter. The sinter is discharged directly into railroad cars at the sintering plants and shipped to the blast furnace in Troy, or to steel plants in Buffalo, Cleveland, Pittsburgh and elsewhere.

Use of magnetite sinter in place of Lake Superior soft ores has resulted in marked blast furnace savings. From experience gained at mills of the Republic Steel Corporation, it has been found that the use of substantial quantities of sinter (40 to 50 per cent) in the charge has raised production from 10 to 19 per cent, decreased coke consumption nearly 15 per cent, flux consumption 20 per cent, and the flue dust production by as much as 50 per cent. (*C. E. Agnew, in Steel, Oct. 4, 1943.*)

Mineville–Port Henry–Fisher Hill

Ore beds were discovered, or known, in the Mineville–Port Henry area as early as the first decade of the nineteenth century, but their development did not begin until the 1820's. After 1849, however, when the mines gradually

TABLE I

ESTIMATED ORE RESERVES AND NOMINAL ANNUAL CAPACITIES OF ADIRONDACK MAGNETITE MINES

Mine	*Reserves*	*Capacities*	
	Crude Ore Long Tons	*Crude Ore Long Tons*	*Magnetite Sinter Long Tons*
Benson	Indefinite	3,000,000	1,000,000
Chateaugay (Lyon Mountain)	400,000,000	1,300,000	425,000
Clifton	Indefinite	500,000	300,000
MacIntyre (Tahawus)	15,000,000	1,200,000	600,000[1]
Mineville—Port Henry			
Harmony	60,000,000	1,800,000[2]	1,000,000
Old Bed			
Fisher Hill	40,000,000	2,500,000	1,000,000
Totals		10,300,000	4,325,000

[1] The primary product is ilmenite.
[2] 20 per cent of Old Bed ore is shipped as lump ore.

Source: *Iron Age*, Jan. 25, 1945, pp. 51 and 53.

came into the possession of the Witherbee and the Sherman interests, later incorporated as Witherbee, Sherman & Co., a rather extensive development of the properties took place. But in the period after World War I, and even more in the depression of the 1930's, this relatively small corporation was unable to continue operations, due to vast changes in the iron and steel industry, and in 1938 the properties were leased to the Republic Steel Corporation. When Republic took over, the capacity of the Mineville properties was roughly 500,000 long tons per year in the form of lump ore, concentrates and sinter; by 1943 this capacity had been doubled. In 1944, the production was 1,609,490 long tons of crude ore. The shipments were as follows: 151,983 tons of lump ore, 759,149 tons of sinter, and 3,810 tons of concentrate. The Mineville deposits consist of two distinct ore bodies, the Harmony vein and the Old Bed vein. Since 1942 the ore from both veins has been handled through a single shaft and the Mineville mine is now "the largest single shaft mine in the country."

Another development in the Mineville–Port Henry area is the Fisher Hill mine which has been operated as a Defense Plant Corporation project by the Republic Steel Corporation since 1941. Up to 1893, this mine had been worked intermittently for nearly a century. Diamond drilling operations carried out in the early 1920's proved that the Fisher Hill ore body would yield at least 40,000,000 long tons of ore. This mine is scheduled to have a yearly capacity of 2,500,000 long tons of crude ore. The Mineville–Port Henry–Fisher Hill mines are believed to represent one of the greatest magnetite deposits in the world.

CHATEAUGAY (LYON MOUNTAIN)

Virtually phosphorous-free magnetite from Lyon Mountain, located in the northern foothills of the Adirondacks, has had a long history in American iron-making. This ore, generally known as Chateaugay ore, seems to have played a prominent rôle as early as 1798, when Zephaniah Platt built the first blast furnace at Plattsburg. The Chateaugay ore bed is situated on the so-called Old Military Tract which was a grant comprising 665,000 acres of land

FIGURE 2.—Lake Sanford and Lake Jinny in the Adirondacks. Since the war began, the National Lead Company's development in this region has supplied the greater part of the country's needs of titanium oxide. (Courtesy of Mr. E. J. Oliver, "Iron Age.")

set apart by the New York legislature in 1781 to satisfy the claims of two regiments raised by the State to protect the frontier settlements from the Indians and other enemies. Geographic factors militated against a rapid and sustained development of this area. Difficult terrain and the remoteness from large centers of population caused high cost mining operations. The region has what seems like insurmountable natural obstacles to the building of railroads or highways. Thus it was not until 1868 that the first steps were taken toward the utilization of Lyon Mountain ores. Even then, the operations were on a very small scale. Ore was dug during the summers and piled up on the surface to be hauled by horsedrawn sleighs during the winter through the wilderness to the Catalan forges on the Saranac River. In the Catalan forge furnace, iron was made directly from ore. The product was a batch of iron, called a "loupe," weighing about 300 pounds. In 1879 a railroad was built connecting the mines with the Delaware and Hudson Railroad, just south of Plattsburg. The years that followed witnessed many changes in techniques and demand. First, pig iron tended to supplant the "bloom iron" produced by the Catalan forges. Later, in the 1890's, the Bessemer process gained ground very rapidly and the low-phosphorous Chateaugay ore was in great demand. When the Bessemer process in steel-making and the puddling process in the making of wrought iron reduced costs more than 50 per cent, American bloomery, which had been the backbone of the demand for Adirondack ore, faded out of the picture. The Catalan forges were abandoned and in their place came the blast furnaces which made low-phosphorous pig iron, first using charcoal and later coke as fuel.

In the years immediately preceding the first World War, a thorough study was made of the Lyon Mountain deposits which revealed that the Chateaugay ore beds contain "an almost endless supply of iron ore practically free

FIGURE 3.—Part of the developments at Tahawus showing magnetite stockpiled for future shipment. During the war period, titanium has been the primary product. (Courtesy of Mr. F. J. Oliver, "Iron Age.")

from sulphur and phosphorous." As a result, the plants and equipment were enlarged and modernized in the 1920's and by 1939, when Republic Steel took over, production had reached a figure of 2,000 long tons of ore per day. In 1943, the concentrating plant had a capacity for treating 4,500 long tons of crude ore daily, from which 1,400 long tons of concentrate were obtained. The total output of crude ore for 1943 was 1,323,000 long tons.

MACINTYRE DEVELOPMENT (TAHAWUS)

The MacIntyre properties lie on the headwaters of the Hudson River about ten miles southwest of Old Tahawus or Mount Marcy, highest peak of the Adirondacks. The two principal reserves of titaniferous ore are Sanford Hill and Iron Mountain, situated in the sparsely populated and relatively inaccessible north woods. Until 1943 the ore had to be hauled by truck for 30 miles to the nearest railroad. A little more than a century ago, this mining center was one of the most active in the entire Adirondack region and great hopes were held for its future. But factors of topography and climate created problems of transportation that proved serious drawbacks to its development. However, a puddling furnace was built in 1837 and a blast furnace was constructed the following year. By 1850 a village by the name of Adirondac had been established at this point. About ten miles to the south of this village, the Hudson River was dammed to permit barge transportation of the iron from the blast furnace at Adirondac. At the dam, also known as the Lower Works, a second village, named Tahawus, was established.

From a magnetic survey made in 1908, it was estimated that there were 63,000,000 tons of very rich ore in four bodies, down to 200 feet. In 1912 a new interest was evidenced in the development of the MacIntyre properties, but nothing came of it; severe winters and great economic distance were the discouraging factors. In 1941 the properties were acquired by the National Lead Co. The supply of titanium, formerly obtained chiefly from India, had been cut off by the war and National Lead was interested in finding a domestic supply of ilmenite "sufficient to guarantee the continued operation of the titanium pigment producing industry of the United States." In addition to its use in the manufacture of white and light-tinted paints, titanium oxide is becoming increasingly important

FIGURE 4.—Part of the concentration plant at Clifton Mines. (Courtesy of Mr. F. J. Oliver, "Iron Age.")

TABLE II

BREAK-EVEN POINT OF ADIRONDACK SINTER BASED ON THE MARKET PRICE OF LAKE SUPERIOR ORES DELIVERED TO PITTSBURGH

	Cost per Long Ton	*Cost per Long Ton Unit of Iron**
Lake Ores (51.5 per cent iron)		
Market Price—Lower Lake Ports	$4.45	$0.0864
Handling and freight to Pittsburgh	1.21	0.0235
	$5.66	$0.1099
Adirondack Sinter (68.5 per cent iron)		
Break-even Mining and Preparation Cost	$4.94	$0.0722
Freight to Pittsburgh	2.58	0.0377
	$7.52	$0.1099

*Cost per long ton unit of iron is the cost of one long ton of ore divided by the percentage of iron in the ore.

in the production of rubber, inks, linoleum, wall board, plastics, and many other products. Extensive core drilling of the Sanford Mountain ore bed indicated that down to the lake level there were approximately 15,000,000 tons of ore containing 16 per cent titanium dioxide. Since this was held to be an adequate supply for the titanium pigment industry of the United States for at least ten years, the National Lead Co. proceeded to build a processing plant which began operations in 1942. In 1943 the average daily production was 3,300 long tons of crude ore, mined by open-cut methods. The products obtained are ilmenite concentrate and magnetic iron concentrate containing vanadium. The content of the Sanford ore is about 16 per cent TiO_2, 33 per cent Fe, and 0.2 per cent V_2O_5. Because of the importance of these minerals to the war effort, the Defense Plant Corporation constructed a sintering plant at Tahawus and a railroad connecting the mines with the Delaware and Hudson Railroad at North Creek, thereby eliminating the former 30-mile truck haul. In 1943 the daily output was about 600 long tons of ilmenite concentrate, averaging 45 per cent TiO_2, and more than 1,200 long tons of magnetite concentrate. In recent years large quantities of magnetite have been shipped to be used in the production of high-specific-gravity concrete blocks for ship ballast. The operations at Tahawus are handicapped by heavy winter snows and sub-zero winter temperatures. For January and February of 1943, the average minimum temperature was 0.9 degrees F. and the lowest recorded was -38 degrees F.

BENSON MINES

The ore deposits of the Benson Mines are situated well to the west of the high peaks of the Adirondack Mountains. Ore deposits in this area were first discovered during the War of 1812 by military engineers who, while building a road between Albany and Ogdensburg, observed a strong magnetic attraction

TABLE III

TYPICAL RAIL FREIGHT RATES FOR MAGNETITE SINTER FROM ADIRONDACK MINES

Destination	*Rate per Gr. Ton*
Alquippa, Pa.	$2.58
Bethlehem, Pa.	2.17
Buffalo, N. Y.	2.00
Cleveland, Ohio	2.855
Massillon, Ohio	2.855
Neville Island, Pa.	2.58
Pittsburgh, Pa.	2.58
Sparrows Pt., Md.	2.38
Swedeland, Pa.	2.175
Wheeling, W. Va.	2.855
Youngstown, Ohio	2.58

Adapted from *Iron Age*, Jan. 25, 1945, p. 50.

on their compasses. The mine appears to have been worked intermittently up to the depression of 1893, when operations were discontinued. It is estimated that by 1893 approximately 370,000 long tons of crude ore, or 150,000 long tons of concentrate of about 60 per cent iron, had been produced. Operations were resumed in 1907 and continued with slight interruptions until 1919. In 1941, Jones & Laughlin Ore Co., a subsidiary of the Jones & Laughlin Steel Corporation, leased 3,200 acres of mineral lands from the Benson Iron Co. Initially it was planned to construct a plant with a yearly capacity of 400,000 long tons of sintered concentrate, but at the request of the United States Government the capacity was increased to 1,000,000 long tons. This volume will require approximately 3,000,000 long tons of crude ore. Financing was accomplished through the Defense Plant Corporation. In the past Jones & Laughlin, whose principal steel works are in the Pittsburgh area, has depended upon the Lake Superior district for its ore. Since the corporation's own workings in that district have yielded about 4,000,000 long tons annually in recent years, the Benson Mines may soon be expected to supply nearly one-half of the ore mined by the corporation.

Ore from the Benson Mines runs from 25 to 30 per cent iron and is concentrated magnetically up to 60 per cent or more. The ore body differs from most other eastern deposits in that it contains both magnetite and hematite. As a rule, however, the two oxides occur separately. Open-cut mining is practiced, with continuous crushing and sintering operations.

CLIFTON MINES

The Clifton Mines are also situated on the western slopes of the Adirondack Mountains, 13 miles north of the Benson Mines. The gently rolling country densely covered with second-growth maple, birch, and hemlock was a vast unsettled forest in 1858 when the ore deposits were just opened. A charcoal furnace was built at Clarksboro, about three miles from the mines, and in 1868 a plant was constructed for the manufacture of steel by a direct process. At one time the mines were connected with the Rome, Watertown, and Ogdensburg Railroad by a 20-mile narrow-gauge railway. Operations at the mine appear to have been carried on for 20 years, during which approximately 10,000 tons of ore were extracted.

FIGURE 5.—A main haulage way at the Chateaugay Mine. (Courtesy of Mr. J. R. Linney.)

In 1941, the M. A. Hanna Co. of Cleveland, Ohio, acquired the property,

FIGURE 6.—Working an open cut mine at Benson Mines on the western slopes of the Adirondacks. (Courtesy of Mr. F. J. Oliver, "Iron Age.")

after extensive magnetometer surveys and diamond-drilling had proved the existence of many millions of tons of relatively rich magnetite. Modern concentration and sintering plants were constructed at the mines and a 12-mile railroad was built from the mines to Newton Falls on the New York Central Railroad. The daily capacity of the installations is 1,800 long tons of abrasive magnetite ore, containing about 42 per cent iron.

OTHER ORE DEPOSITS

In addition to the operations already described, several other ore bodies in the Adirondacks might prove to be suitable for exploration and exploitation. The foremost of these is the extensive magnetite deposits in the Ausable Forks area. Another is a group of somewhat scattered, but in the aggregate substantial, ore bodies near the site of the abandoned settlement of Hammondville, 20 miles south of Mineville where mining operations were carried on intermittently from the late 1820's to the depression of 1893.

BREAK-EVEN PRICE OF ADIRONDACK SINTER

At the present time (1945), the break-even price in Pittsburgh of Adirondack sinter compared with Lake Superior ore, in terms of units of iron, is illustrated in Table II. The break-even point is based upon the prevailing OPA price of $4.45 per ton on Lake Superior ore delivered to lower Lake ports plus freight charges to Pittsburgh of $1.21 per ton, or a total price of $5.66 per ton at Pittsburgh. Since the iron content of the Adirondack sinter averages 68.5 per cent, and the iron content of the Lake Superior lump ore averages only 51.5 per cent, Adirondack sinter can be delivered to Pittsburgh at $7.52 per ton and still compete with Lake Superior lump ore delivered to Pittsburgh at $5.66 per ton. So long as the costs of mining, processing and transporting the Adirondack product do not exceed the break-even point of $7.52 per ton, Adirondack sinter will compete successfully with Lake Superior ore in the Pittsburgh district.

The break-even point of Adirondack sinter delivered to the Mahoning Valley steel producing district is not quite as favorable, being $7.25 per ton because of higher freight rates. Nevertheless, as far as can be ascertained, Adirondack sinter was delivered at this price to the Mahoning Valley in 1943–1945. If this price could be met when lack of labor permitted operation at only partial capacity with resultant relatively high unit costs, it seems reasonable to expect that in the future a more advantageous position will be attained at more nearly capacity operations and lower unit costs.

It follows, then, that the competitive strength of the Adirondack product is greater in Pittsburgh than in the Mahoning Valley, because of the freight differential of 35 cents per ton in favor of the Pittsburgh district. If prices are figured at the mines instead of at the place of delivery, the break-even point at the Adirondack mine, in units of iron, is $4.59 per ton for sinter going to the Mahoning Valley and $4.94 per ton for sinter shipped to the Pittsburgh district.

SUMMARY

Indicated ore reserves of the Adirondacks are very large (Table I). Mining operations are in strong hands and the commitments made by the operators indicate an expectation of permanence, except perhaps in the case of some of the titanium workings at Tahawus. Since operations on a large scale began as early as 1937, or four years before

the United States entered the war, they can hardly be considered to fall within the category of "war babies." In competition with Lake Superior ore, in terms of units of iron, the Adirondack sinter is holding its own and its position is likely to improve. Although the Lake Superior district seems destined to remain the principal source of ore in the United States for a long time, the gradual depletion of its high grade ores will enhance the competitive strength of the Adirondack region. In addition, Adirondack magnetite possesses distinct advantages over hematite in blast furnace operations, because of materially lower coke and flux consumption, and other savings. It thus appears very likely that mining operations in the Adirondacks will expand and become a factor of increasing importance in the future supply of iron ore.

WATER SUPPLY AND PROGRESS IN THE RED RIVER BASIN

J. R. Schwendeman

REFERENCE to use of water by prehistoric man in the Red River Basin is meager. Apparently, like his modern successor in the basin he was alert to his necessities and his selection of homesites as near water bodies as landscape permits is a strong suggestion that water supply was at least one determinant in his choice.

Just who these prehistoric inhabitants of Minnesota were is not clear (Figure 1). In Minnesota, as elsewhere in the United States they are called Mound-Builders. Some reference to them and their mounds in Minnesota occurs in *Aborigines of Minnesota* as follows: "Nearly every county has them, the only probable exception being the area north of Lake Superior. That area, however, has received the least attention, and it is not warrantable to infer from this lack of knowledge that the *Mound-Builders* did not occupy it. The region is rough, sometimes mountainous, and without roads and railroads. When it shall have been settled it may be that scattered evidences of the *Mound-Builders* will be found."

It will be noted that twice in this quotation the prehistoric occupants of Minnesota are called "Mound-Builders." Further information about these Mound-Builders is taken from excavation notes in the same source—"Skulls from the Elk Lake mounds appeared to be distinctly low-browed and neanderthaloid," and another, "Near Graham's Lake, S.W. ¼, N.W. ¼ sec. 20 T. 127–43, an isolated mound having a diameter of 81 feet and a hight (spelling of "hight" from source) of 5 feet. It is on a high ridge between the two larger bodies of water. Several years of cultivation have reduced its hight. On exploring this mound by a shaft at the center, at a depth of 3 feet 9 inches, human bones were found deposited in an earthen pot 13 inches in diameter and about the same in hight. The bottom of the pot was 5 feet 1 inch from the top of the mound. Within it also were six arrow-heads, five broken arrow-heads, one spear-head, one broken drill, and two elliptical-shaped flints, one side of which was flat and the other convex. Outside the pot was a circle of mussel shells, 5 feet 3 inches in diameter. The shells were placed about five inches apart. The bones were all decayed."

This entry appears on excavating a mound near Moose Island Lake: "On being excavated this mound disclosed many human bones, the owners of which must have been 7 feet high!"

In addition to such statements about mounds and Mound-Builders, notations are continually made of lakes, springs, creeks, and rivers in the work of mapping and describing the location of the mounds. Although no statement appears concerning the relationship of the Mound-Builders to these sources of water, yet the natural inference would be that these water bodies were vital to their daily life. The pot and mussel shells found in the Graham Lake mound suggest a close domestic relationship to the surrounding water bodies for food, drink, and cooking water. Thousands of lakes in Otter Tail County

FIGURE 1.—Restoration of prehistoric man's dwelling, Minnesota.

attracted the Mound-Builders as most suitable areas for their homesites. Such concentration of mounds as appears here could scarcely have been due to the incidents of primitive migration or entirely to the combination of the terrain, vegetation, and native land animals.

Quite as striking as the close association of mounds to streams and lakes in Otter Tail County is absence of mounds in the lakeless surface of the Red River Valley proper. It appears plausible that the open flat land of the valley with its swamps and relatively few sluggish streams was not inviting to them, while the thousands of lakes and the comparatively rugged surface of Otter Tail County served the Mound-Builders' needs and wants more effectively. If the winters then, were as cold as at present, all shallow streams and lakes would freeze very deeply or entirely to the bottom (Figure 2), it would have been much more convenient to secure water by chopping through the ice of the deeper lakes and streams and what is even more vital, to get food by fishing through holes in the ice, a practice very common and effective in Minnesota today.

Typical sites for the location of mounds are shown in figures 3 and 4. If the ideal location for Mound-Builders was well drained upland with a commanding eminence or hill, adjacent and convenient to the larger and deeper lakes and streams, then actual mound locations in the Battle Lake and Peever Quadrangles exemplify that ideal. Two sites selected for detailed sketching in figures 3 and 4 are especially significant for no swamps are in the mound vicinity and they are located on commanding elevations. In the Lake Traverse site, actual trails are in evidence leading to spring, river, and lake.

The Otter Tail Lake location is described as follows: "These mounds command a fine view of the lake and the surrounding country." This hill is the one most convenient to the lake and river in the vicinity.

WATER SUPPLY AND USE BY INDIAN AND FRONTIERSMAN

The Basin of the Red River of the North as a home for the Indians, and, from the advent of the white man up

FIGURE 2.—Even the great Mississippi freezes over in winter at St. Paul, Minnesota. Season of 1927–28. Photo by Wright.

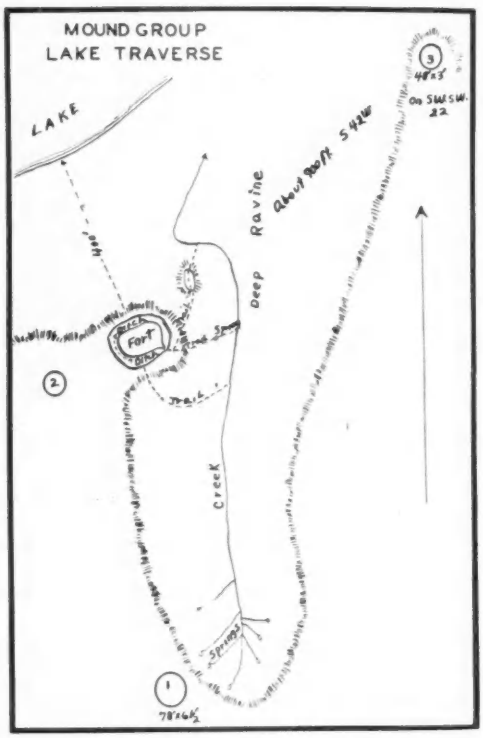

FIGURE 3.—Mounds at junction of Otter Tail Lake and Otter Tail River.

until 1871, was a region of little human significance. Moreover, this slight significance was directly dependent in part upon lake, stream, and spring for its subsistence and development. The few Indians of the vicinity, like their mound building predecessors, established their villages on the deeper and larger lakes and streams, but probably, unlike the farming Mound-Builders they were more directly dependent upon fish and game for food, clothing, and shelter. Fish and certain game such as buffalo, ducks, geese, and muskrats were not only vital for the bulk of the Indians' every day needs, but also, were as directly dependent in their turn upon plenty of readily available water in deep lakes and streams. Scarcely less valuable was the wild rice of the lakes.

The white explorer, fur trader, and settler coming into the basin by water routes of the St. Lawrence, Ohio, and Mississippi systems, found the Indian closely associated with lakes and streams and followed their example in establishing their outposts and fur trading marts. In his turn the fur trader turned to the buffalo for both meat and profit.

Both the fur trader and settler found the Red River further useful as a water route for commercial transportation by steamboat and "scow" or flatboat. It was, however, only after the advent of the railroad in the basin that this primitive frontier occupation gave place to the settler.

INDIANS AND FUR TRADERS

Compared with the half million whites of today's basin population the Indians' occupation of the Red River basin was indeed slight. Warren Upham says: "Comparatively few Indians were able to derive their subsistence by hunting and fishing upon the area of Lake Agassiz or in any other region. Probably the number living at any one time upon the portion of the lake area within the United States did not exceed five thousand."

Specific references to Indian villages within the basin show them to be few and scattered. The Cheyennes lived along the Sheyenne River according to J. R. Cole and various authorities place the Sisitonwan, Warpetonwan, Ihanktonwan, and Titonwan on Lake Traverse. The Chippewas or Ojibways are mentioned on Red Lake and the mouth of the Red Lake River and Pembina.

The nature of Ojibway occupation of the basin can be inferred by this account from *Aborigines of Minnesota:*" At this time (1837) there was no required segregation of the Ojibway, but they roamed over the whole of the state not occupied by the Dakota . . . having, however, certain 'villages' where they spent the winter months and where they sheltered

their women and children in their bark cabins. Such villages were at . . . Red Lake, . . . Pembina on the Red River of the North." The two last mentioned, are in the basin.

The Indians' demand on the basin's water supply was insignificant but his choice of village sites suggests that he was aware of the many advantages to be had by locating on the larger and deeper water bodies such as Red Lake, Lake Traverse, and the Red River of the North.

Relation of the Indian to water is important not only for its use for drinking, sanitation, and cooking food, but very important as the source of supply of food such as fish, game birds (Figure 5 and 6), and wild rice. Much of the fur was taken from animals trapped along water courses for the Red River was a regular haunt of the buffalo.

The quotation on cooking food is noteworthy, "So far as we know, all the Dakota tribes usually cooked their food with *water* made hot by placing hot stones in earthen pots containing the food and necessary amount of water. Meat could also be roasted or even eaten raw, but it is probably that by far the greater portion, so far as it was cooked, was boiled in earthen pots. After the advent of the whites the pot was of some metallic substance, and it is a well known practice to keep it over the fire continuously in order that every chance comer, or any of the family who desired, might partake at once of the contents of the common mess. Such a custom was no doubt a descendent of a similar prehistoric hospitality which required the habitual use of earthen pots." Catlin makes several references to the plains Indians' use of water in cookery: "They make them (pottery) so strong and serviceable, however, that they hang them over the fire as we do our iron pots, and boil their meat in them with perfect success." He speaks of cooking the wild turnip with dried meat and corn.

Of preparing buffalo meat, Catlin says: "During the summer and fall months they use the meat fresh, and cook it in a great variety of ways, by roasting, broiling, stewing, smoking, etc.: and by boiling the ribs and joints with the marrow in them, make a delicious soup, which is universally used and in vast quantities." Catlin also says that the Indians cook their meat more than the civilized people do. He refers to the procuring of water as the women's duty.

Two of the most widely used foods in the basin, pemmican and wild rice (*Zizania aquatica*), require boiling in preparation (Figure 6). Hennepin was given wild rice seasoned with whortleberries to eat when he reached Mille

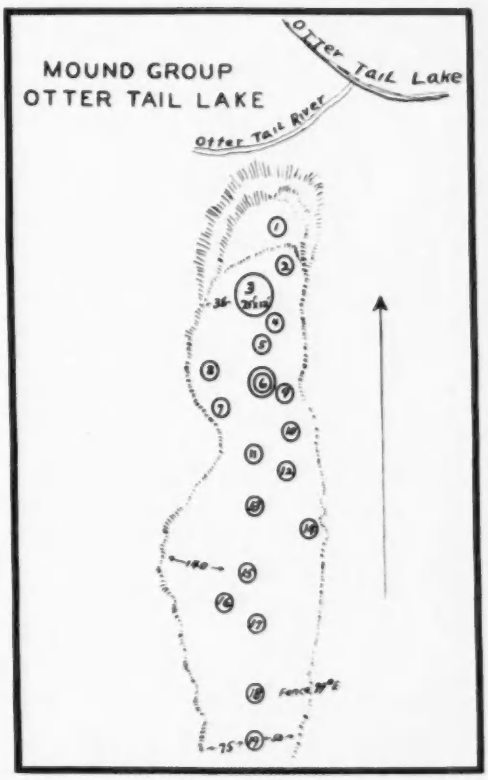

FIGURE 4.—Detailed location of the Lake Traverse Mound Group.

Lacs. According to Radisson, wild rice constituted the chief food of the Dakota Indians in the winter season and Albert E. Jenks gave the number of Dakotas who used wild rice after the Ojibways had occupied the chief area of production east of the Mississippi as from 5000 to 7000.

The Red River Valley was one of the buffalo ranges. The absence of villages in the valley may in part have been due to its use as a hunting ground.

H. V. Arnold writes: "In early times the plains of North Dakota formed a great range for the Buffalo. The bison was a migratory animal, and in winter ranged southward to northern Texas. The increasing warmth of spring, which in that latitude ensues early, urged these animals to take to their northwardly leading trails, and they migrated in vast herds. By the month of June or earlier, they reached the Red River Valley."

Of hunting these bison Mr. Arnold says: "The Wahpetons and Sissetons were accustomed to make journeys to the north along the Red River and as far as the Pembina River, to hunt the buffalo and to wage their predatory warfare against the northern tribes, including the Chippeways."

In referring to the arrival of the Long Expedition at Pembina, August 5, 1823, Mr. Arnold relates: "The day after his arrival, the buffalo hunters came in from the chase, forming a procession consisting of 115 carts each loaded with about 800 pounds of buffalo meat." According to Mr. Arnold the buffalo ranges within the basin of the Red River were along the Sheyenne, the Mouse, the neighborhood of the Turtle mountains, and the upper portion of the Red River Valley.

To the frontiersmen, the bison was as valuable as it was to the Indian. It furnished the trader food, clothing, and

FIGURE 5.—Lakes, sloughs, and wild rice of the Red River Basin, particularly in its eastern part have been homes for countless numbers of aquatic wild fowl.

a commercial commodity. Of this relation Mr. Arnold states: "The buffalo was the harvest of those days—running the buffalo, making pemmican, and shipping furs. Trapping was the business of the spring, buffalo hunting in the summer and fall, and in the winter the trappers, hunters and voyageurs devoted their principal attention to living and they lived right royally on the fruits of the summer's chase. Those with many succeeding years constituted the "good old buffalo days."

The following is an eye witness account of a buffalo hunt described by Alexander Ross and taken from Mr. Arnold's narration. It occurred near Sheyenne and in the vicinity of the site of Fargo, in 1840. "At eight o'clock the cavalcade made for the buffalo; first at a slow trot, then at a gallop, and lastly at full speed. Their advance was on a dead level, the plain having no hollow or shelter of any kind to conceal their approach. Within four or five hundred yards, the buffalo began to curve their tails and paw the ground, and in a moment more, to take flight and the hunters burst in among them and fired. Those who have seen a squadron of horses dash into battle may imagine the scene. The earth seemed to tremble when the horses started; but when the animals fled it

was like the shock of an earthquake. The air was darkened and the rapid firing at last became faint as the hunters became more distant. During the day at least two thousand buffalo must have been killed for there were brought into camp 1,375 tongues. The hunters were followed by the carts which brought in the carcasses. Much of the meat was useless because of the heat of the season, but the tongues were cured, the skins saved and the pemmican prepared!"

The buffalo's relation to water as well as his subsequent fate is written by Mr. Arnold: "The buffalo had but recently disappeared (1870) and had not been gone long enough for their wallows to have become grassed over or their trails obliterated, ... There were then to be seen in places along the streams the worn trails of the buffalo, where they had wended their way down the slopes to drink or to cross from the prairie on one side to that on the other. Where the banks were steep the herds made use of the coulees that occasionally occur in such places, in their movements in and out of the stream valleys." He concluded the buffalo epoch of the basin with this statement: "About the year 1867 or '68, the last of the buffalo that roamed over the eastern part of North Dakota disappeared from the Red River Valley."

The story of the frontier epoch of the Red River Valley is the story of hunting and trapping. Hides and furs were the stock in trade for both Indian and frontiersman. Skins of the smaller animals —elk, deer, antelope, coyote, fox, beaver, mink, muskrat, martin, fisher, wolverine, lynx, and others follow the buffalo in importance.

It will be noted that such animals as the beaver, muskrat, and mink are denizens of lake and stream. Mr. Arnold says of this relation, "The streams of the Northwest were everywhere traversed by the voyageurs in the employment of the fur companies, and their banks were familiar to the trappers and hunters of those times. Probably most of the tributaries of the Red River bear the names that these adventurous men applied to them."

Much of this huge fur trade flowed out of the basin south to St. Paul by means of the "Red River Cart" a two-wheeled vehicle propelled by oxen or ponies. Each cart carried from eight to ten bales of fur and skins.

Charles Cavalier quoted by Mr. Arnold says: "Of robes (buffalo) were packed ten robes to the pack,—of furs there were 500 skins to the pack,—of mink, muskrat, martin, fishers, skunk, and all small animals. Of bear, foxes, wolverines, lynx, there were twenty to the pack!"

The brigades started for St. Paul in the

FIGURE 6.—Wild rice field of northern Minnesota.

later part of June with each brigade consisting of 80 or 100 carts in long trains. In 1840 the Pembina settlements had 1,210 of these carts which later became the basis (1844 to 1870) of the St. Paul trade.

Mr. George Winship in his account says: "The fur trade of the Northwest developed to considerable proportions between 1855 and 1870 and several hundred carts were employed in the traffic between Pembina, St. Joe, and St. Paul." One return train from St. Paul for the Northwest included 500 carts.

The activity in the fur trade added, on the whole, very few people to the Indian population already in the basin. Arnold estimated the half-breed population of North Dakota and Manitoba at 3000 and adds, "In 1869 the number of employees of the Hudson Bay Company in Manitoba and the Northwest totaled 3000."

The Honorable George N. Lamphere in his *History of Wheat Raising in the Red River Valley* gives the twelve counties of the valley proper a population of 1000 in 1870. Speaking of the arrival of Charles Cavalier at Pembina in 1851 Mr. Lamphere says: "At that date the Red River Valley, except the Selkirk settlement, was a howling waste throughout its whole length and breadth. Then there were only four white men in that section, namely: Norman W. Kittson, Joseph Rolette, George Morrison, and Charles Cavalier. There were 1,800 to 2,000 half-breeds,—."

Along with this fur trade epoch a short-lived but dramatic steamboat and barge traffic on the Red River developed which was first based on the fur trade and, later, on the increasing need for supplies in the area, particularly after 1871.

Before the railroads reached Winnipeg, boats were the only means by which bulky freight could go down the Red River. However inadequate the Red River was as a navigable stream, it served a very useful purpose in this early freight movement. Boat movement was along about the entire length of the Red River from Breckenridge, Minnesota to Winnipeg and Fort Gary, Canada, a distance by road of 268 miles and double that distance by the winding route of the Red River. Enroute such major points as Moorhead, Grand Forks, and Pembina served as collecting and distributing points for river freight.

George B. Winship relates the first attempts at steamboating. "In 1859 Capt. Russell Blakely and others bought the steamer Freighter at St. Paul and took it up the Minnesota River with the purpose of transferring it over to the headwaters of the Red River during the spring floods. The effort was almost successful, but the waters receding before the task was completed, the boat was stranded a short distance from the river and was finally abandoned there. Later in the year, however, the steamer Anson Northup was built opposite the mouth of the Sheyenne River, and made the first steamer trip to Fort Gary in Canada."

Following the steamer Anson Northup, steamboats became participants in the transportation of fur and reached their climax in usefulness with the carrying of supplies for the incoming settlers during the seventies and early eighties. By 1886 the steamboat era on the Red River had practically ceased, because of competition with railroads.

Quite a fleet of steamboats operated on the Red River and this account is suggestive—"The valley of the Red River has been very fertile, supplying sufficient produce for freight on boats. During the years of steamboating the whole of North Dakota was in one county—Pembina. In the year 1871 the Selkirk and one barge did the whole

business which amounted to 150 tons. In the year 1874 they had 10,000 tons. In the second year they employed three steamers instead of one, and in the fourth year seven steamboats and twenty barges. In 1882 the amount of freight that was shipped on the river from Pembina to Fargo was 63,303,673 pounds, while millions of feet of logs were annually run down the river to Grand Forks."

In addition to this traffic there appears to have been considerable river traffic in supplying settlers in Canada. Mr. Winship writes, "With the opening up of the country to settlement, however, the conditions soon changed and a very extensive traffic developed. The emigrants, pouring into the Canadian domain, required lumber and other building material, and household and other supplies. These were shipped to St. Paul by rail, and from the terminus of the railroad they were freighted to the Red River valley by ox carts, and from McCauleyville to Winnipeg by steamboats and flatboats. During 1870 no less than forty flatboats, or scows, were constructed at McCauleyville with a carrying capacity of from ten to forty tons each. These were floated down the river to Winnipeg, where they were taken apart after being unloaded, and the lumber in them sold. The river presented a busy scene with its numerous fleets of scows as well as several steamers plying up and down."

After the first attempt to float the steamer, Freighter, from St. Paul to the Red River failed, all subsequent boats were built or assembled on the Red River itself after being freighted to it in parts. Winship relates, "The river traffic developed to considerable proportions between 1875 and 1880. A boat yard was established in Grand Forks by D. P. Reeves, and the steamer Sheyenne was built here, and later other steamers. The steamers, Minnesota and Manitoba were built at Moorhead in 1875. About the same time N. W. Kittson and others organized the Red River Transportation Company, which has been in business and navigating the river continuously ever since. The steamer, Alpha, was built by the company at McCauleyville and later the steamer Alsop was built by H. W. Alsop of Fargo. He also bought the steamer Pluck, at Brainerd, transported it by rail to Moorhead where it was lengthened and again launched. These boats were later bought by the Red River Transportation Company, and subsequently the same company constructed the steamer Grand Forks and numerous barges. In addition to the steamboats plying the river, numerous flatboats were in commission hauling northbound freight, the boats being taken apart and the lumber sold at the end of the trip."

Although navigation of the Red River appeared quite active during this early era, it was not without its problems. Distance between points was greatly increased by the necessity of following the winding channel. In *History of the Red River Valley* we are informed that, "The Red River of the North is neither wide nor deep, but navigable from Wahpeton to its mouth. It is 186 miles from Wahpeton to the international boundary line, but the river is so crooked a boat travels nearly 400 miles in going that distance."

Goose Rapids are the only rapids listed; they are small but act as a barrier. The problem of Goose Rapids appears in this account by Mr. Arnold: "While on his return to St. Paul, Captain Blakely learned of the purchase of the Anson Northup (Steamboat) by his associate, Mr. Burbank. He appears to have returned at once to the valley. Under her new ownership the boat made another trip to Fort Gary. The waters

being now low, the boat could not get through the Goose Rapids. Her cargo was unloaded, the intention being to have it taken to its destination by McKey's carts, when the timely arrival of Captain Blakely resulted in the construction of wing dams, and the goods being reloaded, the boat proceeded safely to Fort Gary; but the crew returned to St. Paul by a cart train."

Mr. Arnold further gives an account of low water problems as related by Nick Huffman: "Stations had been built along the (stage) road, and teams by the hundred were hauling freight for Fort Gary and Georgetown. The old steamer Anson Northup was then making regular trips from Georgetown to Fort Gary. There was life and good pay everywhere. Captain Munn sent for me to work on the steamboat, which they then called the Pioneer. There was no pleasure in this, as the water was low and the men had to haul on the lines all day and chop wood all night by lantern, and we had a hard time to get the boat to Georgetown!"

The boats were not large, hence did not draw much water. The International is described as being 137 feet in length, 26 feet beam, and rated 133 tons.

The steamboat epoch, although it continued until the late eighties, was doomed by the entry of the railroad to the valley in 1871 when a new era of settlement and development of the Red River region began. Mr. George B. Winship says: "—the date of the permanent settlement of the Red River Valley may properly be fixed in the spring of 1871 when with the establishment of a line of stage coaches by Blakely and Carpenter, of St. Paul, between Fort Abercrombie and Winnipeg, or Fort Gary, as the northern frontier post was then known, together with the

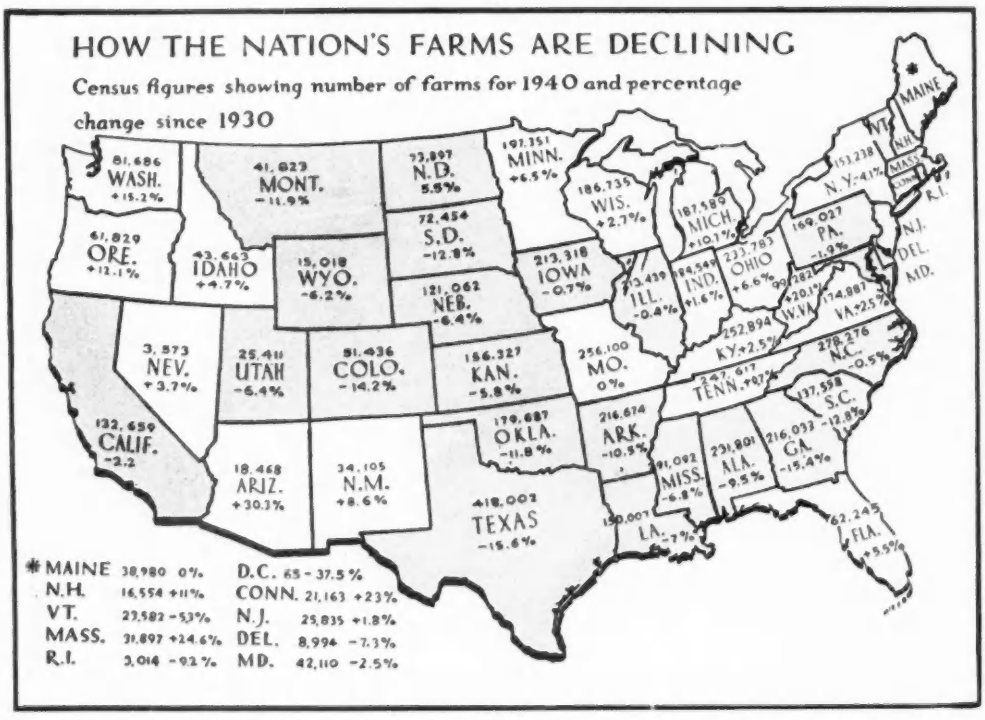

FIGURE 7.—Minnesota shows a gain in the number of farms. The Minnesota side of the Red River Basin also shows a gain in the farm population for the same period. Reprint from *Newsweek*, Feb. 17, 1941.

initial trip of the steamer, Selkirk, built at McCauleyville the previous winter, the first actual settlers took up their abode here with the intention of making this fertile valley their permanent home. . . . It is true there were a few settlers at different points prior to 1871, buffalo hunters, speculators, fur traders, . . . Pembina, the oldest settlement began about 1800 but practically from this date until 1871 there was little progress made in the settlement of this vast empire."

Of the importance of the railroad which arrived at Moorhead in the center of the valley in the fall of 1871 *The History of the Red River Valley* says: "The Northern Pacific Railway, the Great Northern, and other lines for the transportation of the products of this portion of the state of North Dakota, have been the forerunners of the settlement of the Red River Valley. The transportation problem, by the incoming of these roads, settled the question as to the advisability of farmers locating in the state, and to the foresight and public spirit of James J. Hill and others, who paved the way for a commonwealth by the building of these roads, all honor is due. The six or seven hundred thousand people of North Dakota could hardly depend upon the dog sledge and the travoise of former times, especially when it is an undisputed fact that the freight trains of these railroads are the longest and carry the heaviest burdens of any trains in the world. Between 1846 and 1865 many thousands of Red River carts were engaged largely in the transportation of the furs and buffalo hides which constituted the chief products of North Dakota to St. Paul. The navigation of the Red River began in 1859, and as many as a dozen steamboats were engaged in the traffic, but with the advent of the railroads the steamboat trade fell off rapidly. And the stage lines did a large business also in the valley until supplanted by the railroads."

WHITE OCCUPATION OF THE RED RIVER BASIN

With the advent of the railroad to the Red River basin and the consequent influx of settlers a new era began in use and supply of water. The few wandering Indians were replaced by the thousands of home making white settlers; uncouth trappers and traders gave way to skilled artisans and merchants; beast and fowl of the farmer made up for the slaughter of buffalo and game; farmers patterned the unbounded prairie in crops; scattered and ragged Indian villages and fur trading posts were replaced by numerous substantial and well arranged cities and villages; dramatic and picturesque ox carts, dog sledges, travois, and steamboats became relics as the direct routes and powerful carriers of the railroads and highways spread over the basin.

With each of these changes in the occupation of the basin, the variety of uses for water and the amount used increased immeasurably followed by new, as well as, increased demands on this resource. Natural and haphazard resort to water of the frontier changed to carefully developed supplies and elaborate and well organized systems of the white man. As a consequence, changes occurred in the water supply with developing problems in conserving both its quantity and quality.

The early settlement of the basin to 1920 was swift and extensive. Lamphere (Table I), shows a population of only 1000 in 1870 but it increased to 56,000 by 1880. In 1890, the United States Census (Table II) shows the valley counties well occupied with 161,049 settlers—an increase of 105,049 in the decade or twice the 1870–1880 influx. By 1900 the population of the 12 river counties reached 221,818 with the ac-

TABLE I

POPULATION GROWTH IN THE RED RIVER VALLEY FOR THE 12 COUNTIES BORDERING THE RIVER

1870	*1880*	*1890*	*1900*
1,000	56,000	166,000	350,000*

Data Hon. George N. Lamphere.
*Mr. Lamphere gave the 1900 population as an estimate.

cretion of another 60,000 home makers. Several of these counties ceased to grow after 1900, and while the total population gained each decade, the gain was comparatively small. The entire basin, however, shows a rapid increase in population to 1920 (Table III).

By 1910 the number and distribution of incorporated places was essentially the same as at present. The United States Census lists 170 incorporated places in the basin then, as compared to 219 at present.

Some analysis of the recovery of the basin's total population increase from about 4,000 in 1920–1930 to 24,000 in 1930–1940 is worthwhile. The Minnesota side of the basin shows 23,312 of this last decade gain while the North Dakota side shows only 2,648 and the small South Dakota segment of the basin shows a loss of 1,869. Furthermore, the Minnesota gain appears in every phase of population distribution. Minnesota farm and unincorporated village population gained 5,781; incorporated places less than urban size gained 6,967, and urban population gained 10,564; whereas in the North Dakota part of the basin urban population gained 9,231; incorporated places under urban size 6,622. The farm and unincorporated village population of the North Dakota side lost 13,205 leaving only a net gain of 2,648 for this part of the basin. Two of the North Dakota Red River valley counties bordering the river, Traill and Richland, show a slight net loss in total population while all of the Minnesota counties bordering the Red River show some gain.

Now for the first time in the history of the basin, the Minnesota side of the basin is carrying the heavier population load. Previous predominance of basin population in North Dakota is probably related to its comparatively better natural drainage while the late increase in the Minnesota part of the basin appears to be related to the general exodus from the drought stricken midwestern states during the past dry-cycle decade—the better watered Minnesota

TABLE II

POPULATION OF 12 COUNTIES (ABSTRACTS OF THE THIRTEENTH AND FIFTEENTH UNITED STATES CENSUS)

County	*1890*	*1900*	*1910*	*1920*	*1930*	*1940*
Pembina	14,334	17,869	14,749	15,177	14,757	15,671
Walsh	16,587	20,288	19,491	19,078	20,047	20,747
Grand Forks	18,357	24,459	27,888	28,795	31,956	34,518
Traill	10,217	13,107	12,545	12,210	12,600	12,300
Cass	19,613	28,625	33,935	41,477	48,753	52,849
Richland	10,751	17,387	19,659	20,887	21,008	20,519
Kittson	5,387	7,889**	9,669	10,638	9,688	10,717
Marshall	9,130	15,698	18,338	19,443	17,003	18,364
Polk	30,192	35,429**	36,001	37,090	36,019	37,734
Norman	10,618	15,045	13,446**	14,880	14,061	14,746
Clay	11,517	17,942	19,640	21,780	25,120	25,337
Wilkin	4,346	8,080	9,063	10,187	9,791	10,475
Total	161,049	221,818	234,424	251,642	258,803	273,977

**The population of these counties were reduced by the formation of new counties back from the river which partly encroached on their former area.

TABLE III

Year	Basin Population	Numerical Increase
1890	228,092	147,185
1900	375,277	67,729
1910	443,006	42,198
1920	485,204	3,887
1930	489,091	24,071
1940	513,182	.....

side of the Red River basin offers the first haven of refuge for these stricken migrants on the eastern side of the drought belt (Tables I and II).

The mid-western states of North Dakota, South Dakota, Nebraska, Kansas, and Oklahoma show a net loss while Minnesota shows among the largest net gains in the Union. Corroboration of this situation is shown by a map (Figure 7) which shows the change in the number of farms by states in the past ten-year period. The number of farms in all of the mid-western and Great Plains states declined while the farms in Minnesota increased by 6.5 per cent.

The increase in urban population for the basin as a whole, while not striking, has been fairly consistent showing a gain each decade.

Urban population, however, places a greater strain on water supply than the number of population increase indicates. Concentrated population requires water supply for a single locality which is spread over a greater territory in rural areas. The increased uses of water by urban residents further extends the demand on local water supply.

TABLE IV

URBAN POPULATION INCREASE

Year	Urban Population	Numerical Increase
1890	22,200	.....
1900	38,008	15,808
1910	59,755	21,747
1920	76,965	17,210
1930	91,537	14,572
1940	111,332	19,995

Increased demand for water by the larger cities is shown by the fact that the city of Fargo with 32,580 people in 1940 leads all the basin cities in per capita water consumption with 100 gallons per person per day. The average for the basin for reporting organized systems is 43 gallons per person per day while the average for the Goose-Pembina sub-basin, in which Fargo is included, is only 41 gallons per person per day.

Among the 13 cities classified as urban, in the basin, there are exceptions to the steady increase shown in Table IV. Crookston, Minnesota had a population of 7,559 in 1910 which declined to 6,321 in 1930 and recovered somewhat to 7,161 in 1940.

The total incorporated village population for the basin increased steadily from 1890 to 1920, remained stationary until 1930, and then resumed its increase to 1940. Table V shows the nature of this increase and its relation to the urban and farm and unincorporated population groups:

In several respects the trend of the small town population requires analysis. In the eight sub-basins in North and South Dakota and Minnesota very little change occurred between 1920 and 1930, however, both Minnesota and South Dakota showed net losses in population during this decade and North Dakota only a net gain of 470. Both North Dakota and Minnesota gained appreciably in small town population in the decade 1930–40, almost the same number

TABLE V

Year	Incorporated Village Population	Numerical Increase
1890	23,435	.....
1900	56,907	33,462
1910	86,038	30,131
1920	94,437	8,399
1930	94,497	60
1940	107,845	13,348

each—6,967 for Minnesota and 6,622 for North Dakota.

The total gain of 60 in the period 1920–30, however, does not entirely reveal the truth of the small town situation at that time. Of a total of 100 incorporated towns, between the size of 300 and 2,500 population in the Minnesota and North Dakota parts of the basin, 79 showed more or less loss between 1920 and 1930—42 in North Dakota and 37 in Minnesota. The small net gain of 60 for the basin came through five new incorporations adding a total population of 1,721 to the incorporated village population. Actually, the incorporated city and village population lost 1,661 people in this decade. During the 1920–30 decade the small town appeared doomed to be composed only of a gas station and grain elevator.

Strangely enough, practically all of these towns either held their own in population or gained appreciably in the succeeding ten years from 1930–40. There were, of course, some few marked exceptions such as the town of Hope, North Dakota which continued its decline from 909 in 1910 to 474 in 1940. Few significant changes appear in the status of the towns under 300 population, or, perhaps the lack of change in them is significant in that the service which they perform to the community, while not great, is nevertheless indispensable.

The water supply problems of these small towns lie in their small size, large number, and wide distribution over the basin. With a population too small for successful organization of water supply they are too widely scattered for cooperation into groups of water supply units. Practically all of the towns under 300 population have no organized water supply systems and the number of towns in this size classification form about half of the incorporated towns under 2,500 population.

TABLE VI

POPULATION TREND IN FARM AND UNINCORPORATED VILLAGES

Year	*Population*	*Numerical Change Total*
1890	182,457	(1,906 in 1870)
1900	280,362	97,905
1910	297,213	16,851
1920	313,802	16,589
1930	303,059	−10,743
1940	294,005	−9,054

Farm and unincorporated village populations have shown the greatest changes in the basin. These population groups are most vital to the occupation of the basin and form the greater part of the total number of people decreasing from about 80 per cent in 1890 to around 60 per cent in 1940. The fertile and level lands of the basin were rapidly taken up in farmsteads and this farm and associated small village population increased sharply to 1900 and then slowly to 1920 and since that time has steadily declined (Table VI).

The loss in this population group of almost 20 thousand between 1920 and 1940 can, in part, be assigned to new incorporations of villages—4,468 persons between 1920 and 1930 and 585 persons between 1930 and 1940, or a net loss of about 5,000 persons for the farm and unincorporated village group for this period. Most striking point is that the Minnesota side of the basin has practically recovered its 1920 high in farm and unincorporated village population with 158,858 in 1940—only 631 under 1920. On the other hand, North Dakota continued its marked decline to 129,921 in 1940 or its lowest figure for this population group since 1880.

The distribution of this major population group uniformly over the basin, largely by farmsteads, creates as many

FIGURE 8.—A wheat field in the vicinity of Fargo, North Dakota in the flat Red River Valley. There are no better wheat lands in the world. Anderson photo.

water supply problems and demands as there are farmsteads and is, without doubt, the foremost water supply problem in the basin as well as the most difficult to solve satisfactorily.

Along with the rapid occupation of the valley by the white man came an equally marked change in its culture. The untouched prairie of the Indian and the buffalo gave way to the regular patterns of cultivated field crops. By 1900, 61 per cent of the entire area was in farms, and of this, 72 per cent was actually improved for cropping. By 1930 the farms occupied 77 per cent of the entire area with 92 per cent of farm land in crops. Development of agriculture changed the nature of water supply and demand. Introduction of farm animals into the basin, processing of animal products for market, and irrigation add immensely to demand for water. Moreover, the change from the frontier dependence upon surface water, and the farmer's dependence on well water while it has permitted the wide occupation of the basin, may lead to serious depletion of the water supply of both surface and ground water.

TABLE VII

ACREAGE OF THE PRINCIPAL CROPS GROWN IN THE RED RIVER VALLEY, MINNESOTA AREA TOTALED FROM THE COUNTY REPORTS IN 1934 AS REPORTED BY— KITTSON, MARSHALL, POLK, RED LAKE, NORMAN, CLAY, WILKIN, AND TRAVERSE COUNTIES— 1935 CENSUS

Crop	*Total Acreage*
Corn for all purposes (harvested for grain)	261,055
Wheat threshed	499,019
Oats threshed	487,251
Barley threshed	296,412
Rye threshed	62,051
Mixed grains threshed	18,538
Flax threshed	196,631
Potatoes	105,072
Sugar beets	12,348
Hay and forage	740,232
Timothy and clover	21,382
Sweet clover and Lespedeza	88,158
Alfalfa	70,082
Small grains hay	74,415
Other tame hay and wild grasses	481,970
Legumes for hay	718

Dr. J. H. Sheppard, late President of the North Dakota State College of Agriculture, begins the agricultural history of the Red River Valley with the Lord Selkirk colony in 1817. Although regular progress in agriculture in the basin did not begin until 53 years later, the Selkirk Colony established the growing of wheat which later became the first great agricultural commodity of value to the basin. Indeed it was the wheat crop which caused the rapid peopling of the baisn and gave it its prosperity.

Of Lord Selkirk's contribution Dr. Sheppard says: "That season (1818) Lord Selkirk purchased two hundred bushels of seed grain from the United States and brought it in for the use of the colonists. This wheat cost Lord Selkirk a thousand pounds sterling. He secured the seed wheat together with some seed oats and barley at Prairie du Chien, Wisconsin and transported it by boat from that point to Fort Gary. The boat was brought up the Mississippi and Minnesota Rivers to Lake Traverse and from there into Big Stone Lake, where through good fortune, the water was unusually high, so that the passage was safely made. From that point the shipment passed down the Red River to old Fort Gary, where it was received by the Scotch settlers with great rejoicing. This shipment of wheat is said to be the original source of supply of the Scotch 'Fife' wheat of the Northwest. The seed was sown by the colonists in 1820 and brought a good crop—the first grain crop produced in the Red River Valley. . . . . The success of the Selkirk colony was such that after the season of 1820, they were never without wheat enough to supply the Hudson Bay Company for their outposts, what they needed for their own use, and to allow them to follow the frugal plan of retaining enough for food and seed to carry them over a two-year period, in case a second scourge of locusts should overtake them."

Of the value of wheat to the rapid development of the Red River Valley the Honorable George N. Lamphere has this to say in his *History of the Red River Valley:* "Another leading factor in the settling of the country has been the so-called 'Bonanza' farms. Those demonstrated on a large scale the practicability of producing wheat at a profit on the flat lands of the valley. They advertised the results of great operations, and made known to the world the wonderful possibilities of the region." (Figure 8.) The other factor Mr. Lamphere alluded to in this statement was the development of the railroads which were capable of carrying the great produce to market as well as bringing in settlers. In 1898 acreage planted to wheat in the 12 counties bordering the Red River was 3,019,489 and the yield 48,117,756 with a value of $28,870,653.

In 1910 the basin yield of wheat was 99,000,000 bushels with a decline to 52 million in 1920. The Minnesota Annual Crop and Livestock Statistics and Agricultural Statistics of North Dakota for 1938 to June 1940 together, place the wheat yield of the 12 valley counties at 22,225,421. While wheat has in recent decades given place to diversified farming, it has played a vital part in developing the valley.

A list of the present prominent crops of the basin and some suggestion of their relative importance is shown in Table VII arranged from the reconnaissance soil survey of the Red River Valley.

The importance of the crops to the valley is mainly in the diversification of agricultural enterprises that it supports. Feed for livestock furnished by these crops is most important; sale of animal products has been a tremendous regula-

tor and stabilizer of farm income. Addition of livestock to the farm has greatly aided in soil conservation practice through rotation of crops and the manure returned to the fields. But these farm animals have greatly increased the farmers' need for water. Since such water is drawn almost entirely from wells for most of the basin the importance of the ground water from the glacial drift is again emphasized.

Modern, highly bred stock, constitute the farm animals of the basin (Figure 9). High grade and highly specialized livestock need a constant supply of pure water. In the writer's field investigation, farmers constantly emphasized the value of a constant pure water supply, particularly for dairy cattle. Drinking cups placed so that clean water of proper temperature is constantly under the dairy cow's nose brings the greatest profits. Every dairy farmer in the area, either had cups for his cattle or wanted them. The naturally filtered water from the deep wells of the basin at constant temperatures fits this demand in livestock program.

The number of cattle in the basin greatly outnumber the human population. Table VIII shows their number and distribution by counties and parts of counties. When a county is only partly in the basin the number of cattle was prorated according to the density of cattle in that county for that part of the area of the county in the basin. Next to the comparatively large number of cattle, their wide and rather uniform distribution over the basin is significant in that it reflects the uniform topography and uniform availability of water. The greater density of cattle in Minnesota may be due to more abundant supplies of pure water, or, it may be due to the earlier development of dairying in Minnesota which may gradually spread over the North Dakota side of the basin particularly the Red River portion.

FIGURE 9.—Reserve champion steer sold for $608.40 raised by Wayne Naugle, Ada, Minnesota.

Sheep are next in number of farm animals (Table IX), not counting the poultry which number more than all the other farm animals combined. While sheep require less water than other farm animals, there is the problem of keeping a supply open for them in winter, necessitating the water tank, either open in the barn or kept from freezing out of doors in the severe cold by tank heaters. The water tank is the most common means of providing water for all livestock in the basin, but it particularly applies to sheep since any individual supply such as the cup for the dairy cow is not expedient. Sheep are quite evenly distributed over the basin (Figure 10).

Horses and swine are fewer in number compared with other farm animals, moreover, the number of horses is steadily declining. The eight counties bordering the Red River on the Minnesota side are shown by the Soil Survey tabulation to have had a horse population of 88,515 in 1930 and 79,122 in 1935—a drop of nearly 10,000. Horses share with cattle the need for constant large supplies of pure drinking water for which the farmer must make provision.

Swine were fewest in number of the

TABLE VIII

1935 CENSUS OF CATTLE OF ALL AGES FOR MINNESOTA, AND 1940 CENSUS FOR NORTH AND SOUTH DAKOTA

MINNESOTA

Total for State—3,179,332

Total for Counties in Basin:

County	*No. Cattle*
Becker	27,221
Beltrami	16,500
Bigstone	1,370
Clay	33,872
Grant	18,043
Kittson	24,241
Koochiching	500
Mahnomen	14,345
Marshall	40,174
Norman	35,532
Otter Tail	63,500
Pennington	10,909
Polk	67,987
Red Lake	16,680
Roseau	27,000
Stevens	19,000
Traverse	16,612
Wilkin	22,644
Minnesota total	456,130

SOUTH DAKOTA

Total for Counties in Basin:

Roberts	13,500
Marshall	12,500
Total for South Dakota	26,000

Total for Basin:

Minnesota	456,130
North Dakota	307,814
South Dakota	26,000
	789,944

NORTH DAKOTA

Total for State—1,048,541

Total for Counties in Basin:

County	*No. Cattle*
Barnes	24,000
Benson	5,000
Cass	26,697
Cavalier	17,500
Eddy	7,500
Foster	1,500
Grand Forks	26,498
Griggs	15,652
McHenry	4,000
Nelson	15,000
Pembina	20,291
Pierce	5,000
Ransom	17,000
Richland	36,228
Rolette	3,000
Sargent	16,500
Sheridan	11,500
Steele	13,037
Towner	4,500
Traill	13,611
Walsh	20,800
Wells	3,000
North Dakota total	307,814

State Farm Census (1940) for North and South Dakota and (1935) for Minnesota.

farm animals in the eight Minnesota counties bordering the Red River, totaling 83,382 in 1930 and 45,479 in 1935. The Government measures respecting the reduction of swine probably accounts for the drastic reduction of swine during this five year period. The fact that the total number of swine is not large in the basin can probably be ascribed to the lack of corn in the form of grain for feed. As consumers of water, swine get their water in part second hand from kitchen slops and do not constitute the same demand for large quantities of pure water as do cattle or horses.

Considering this huge total animal population and its close association with the well water supplied by the farmsteads, it appears that any appreciable diminishing of the ground water supplies of the basin would be tragic to its human occupation. It can safely be said that the exhaustion of the ground water would largely depopulate the basin due to the loss of livestock alone, even though its human population could find sufficient water for its own use.

DRAINAGE

In the occupation of the Red River Basin, drainage was considered an essential measure. That drainage was

necessary if land in the basin was to be extensively occupied for farming is indicated by the original swamp land acreage recorded for some of the basin counties on the Minnesota side. Furthermore, the extent of the land drained in some of the Minnesota counties shows that much of the land, not in actual swamp, required drainage before it could be successfully farmed. Table X, taken from Palmer's treatise on swamp lands and drainage in Minnesota shows that many of the Red River Valley counties had a high swamp land acreage. Table X shows that not only was the swamp land drained but also that more than half of the entire acreage in the counties needed draining.

Hundreds of miles of ditches and consequently considerable expenditure of money was required to drain the land. In Clay County, Minnesota 186 miles of ditches were constructed at a cost of $328,224.00. It is suggestive to note that most of the ditches are in the valley. Very few ditches are in the higher, more uneven eastern part of the county. Flat land of the lake plain evidently did not drain rapidly enough in the spring or following the heavier rains. By draining,

TABLE IX

1935 CENSUS OF SHEEP OF ALL AGES FOR MINNESOTA, AND 1940 CENSUS FOR NORTH AND SOUTH DAKOTA

MINNESOTA

Total for Counties in Basin:

County	*No. Sheep*
Becker	15,580
Beltrami	10,530
Bigstone	1,310
Clay	10,728
Grant	2,500
Kittson	24,100
Koochiching	500
Mahnomen	11,749
Marshall	40,154
Norman	11,155
Otter Tail	23,340
Pennington	16,864
Polk	36,091
Red Lake	10,216
Roseau	31,149
Stevens	2,000
Traverse	1,600
Wilkin	9,973
Minnesota total	259,539

NORTH DAKOTA

Total for Counties in Basin:

County	*No. Sheep*
Barnes	14,000
Benson	6,500
Cass	20,300
Cavalier	16,800
Eddy	6,500
Foster	3,500
Grand Forks	31,142
Griggs	28,363
McHenry	3,000
Nelson	30,380
Pembina	48,032
Pierce	5,000
Ransom	23,500
Richland	24,477
Rolette	3,000
Sargent	21,000
Sheridan	10,000
Steele	19,165
Towner	3,500
Traill	8,545
Walsh	11,878
Wells	5,000
North Dakota total	343,582

SOUTH DAKOTA

Total for Counties in Basin:

Roberts	13,100
Marshall	11,000
Total for South Dakota	24,100

Total for Basin:

Minnesota	259,539
North Dakota	343,582
South Dakota	24,100
	627,221

State Farm Census (1940) for North Dakota and South Dakota and (1935) for Minnesota.

TABLE X

ORIGINAL SWAMP LAND AND DRAINED LAND IN SOME OF THE RED RIVER BASIN COUNTIES OF MINNESOTA

County	*Area in Acres*	*Acreage in Swamps*	*Acreage Drained*	*Per Cent Drained of Total Area*
Clay	667,520	230,000	284,717	42.6
Kittson	711,040	100,000	268,618	37.7
Marshall	1,244,320	258,240	1,349,064*	
Norman	550,400	.....	164,463	29.8
Pennington	388,480	.....	284,945	73.4
Polk	1,266,560	100,000	997,441	78.7
Red Lake	276,480	.....	241,568	87.4
Roseau	968,800	533,680	168,470	17.5
Wilkin	476,800	.....	198,183	41.5
Totals	6,550,400	1,221,920	3,957,369	Average Per cent 51.0

Palmer, Ben. *Swamp Land Drainage with Special Reference to Minnesota*, University of Minnesota, 1915.
*No explanation is provided for the excessive acreage drained by Marshall County. It is possible that the acreage includes that drained by the county before the formation of Beltrami County.

the value of the fertile land for cropping was higher and probably rightly so.

Just what effect this surface drainage has had on the storage of ground waters is not known. It appears logical to say, however, that the surface water drained from the flat lacustrine plain above the relatively impervious lacustrine silts and clays had little relation to the ground water content of the till beneath.

In striking contrast to the former extensive drainage, irrigation is now appearing n the valley for certain crops such as sugar beets (Figure 11) as a result of the series of dry years since 1929. Only an occasional farm, usually specializing in some crop demanding considerable moisture, has as yet, set up some type of irrigation system.

The Fairmont Creamery Farm just south of Moorhead, Minn. irrigated an alfalfa field during the summer of 1940. Water was pumped from the Red River and sprayed over the field by jets from a system of six inch pipes. These pipes were equipped with hand holds and could be moved over the fields as the irrigation progressed in somewhat the fashion of the urban lawn spray system (Figure 12, Plates A and B). The Charles Peterson Truck Farm just north of the city limits of Moorhead has

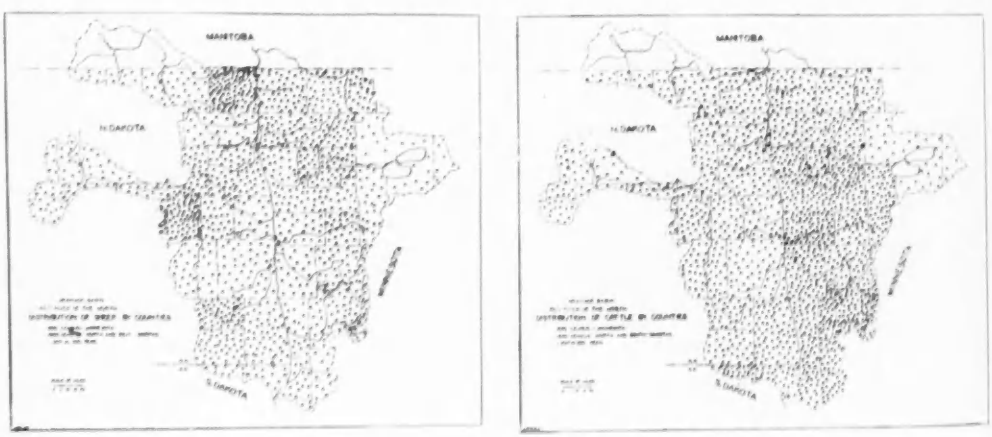

FIGURE 10.—Plates A and B. Distribution of sheep, and Distribution of cattle in the Red River Basin.

FIGURE 11.—The sugar beet's demand for moisture is large and an increasing acreage of this crop is being irrigated.

the same system but is dependent upon the filtration plant for its water supply (Figure 12, Plates C and D).

The Wiedemann Farm about six miles east of Moorhead grows sugar beets with irrigation and has had marked success (Figure 13, Plates A, B, C, and D). The source of water for the Wiedemann Farm is a well, which Mr. Wiedemann claims can be pumped at 4,000 gallons per minute. The well water is pumped into lateral ditches and flows by gravity along the side of the beet field and is released over the field by sluices. (Figure 14, Plates A, B, C, and D). If ground water supplies are adequate, this type of irrigation should hold considerable promise as future security against drought. It is questionable if the ground water supplies are available in quantity for extensive irrigation.

Near the Wiedemann well is a huge gravel pit at present being worked by drag buckets. This pit was investigated

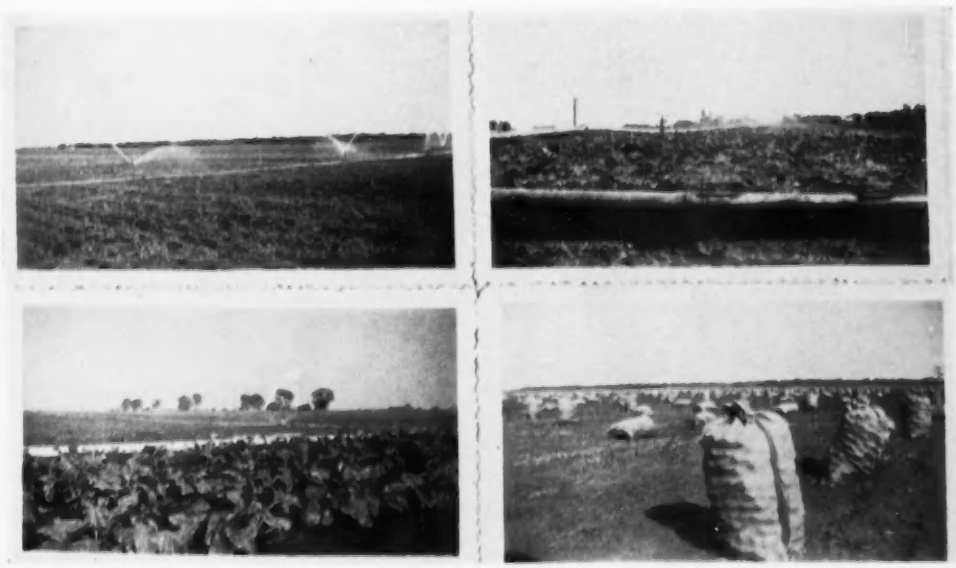

FIGURE 12.—Plates A and B show overhead pipe irrigation in operation on an alfalfa field of the Fairmont Creamery Farm just south of Moorhead. The pipes have hand holds and are carried from place to place by hand. Plate C shows the same system of pipe irrigation in operation on Charles Peterson truck farm just north of Moorhead. Plate D shows a remarkable yield of onions on the irrigated Peterson truck farm.

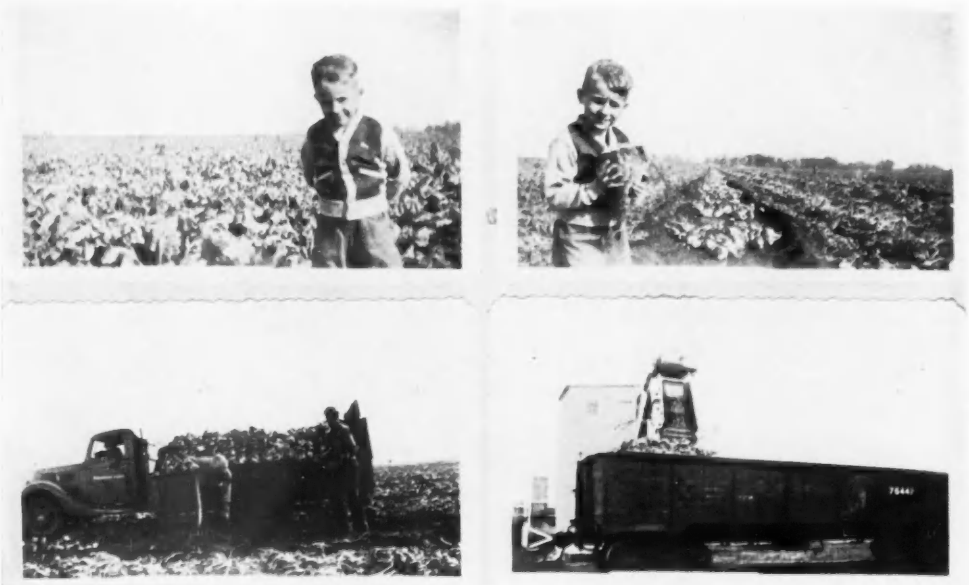

FIGURE 13.—Plates A, B, C, and D show the Wiedemann sugar beet field during the harvest of 1940. Loading of beets on the freight car is done about one mile from the farm.

by the writer and shows the characteristic stratification and cross bedding of delta structure (Figure 14, Plates A and C). Other pits occur in line due north in this vicinity. These pits are filled with water within ten or 15 feet of the surface of the plain. Just how this delta formation was developed in

FIGURE 14.—Plates A, B, and C show the water-filled gravel and sand pit near the Wiedemann farm well from which the water is pumped for irrigation of several hundred acres of sugar beets. Plate D shows a sluice from a lateral ditch from which the water flows out on the field. The water flows along by gravity.

the middle of the lacustrine plain and subsequently entirely obscured by lake sedimentation is not clear. It does appear, however, that the abundant water in the Wiedemann well has its source in the neighboring water supply stored up in the sand and gravels of this delta (Figure 14, Plates A, B, C, and D). The pits prove a valuable source of sand and gravel in the midst of a plain otherwise devoid of such material.

Industrial development in the basin is very slight, associated almost entirely with the processing of agricultural products such as flour milling, creameries, and packing plants. Creameries listed for the basin number 150 with total value of products in 1930 of $28,694,029.

Creameries, packing plants, and the sugar beet factory at East Grand Forks, Minnesota consumed considerable water. The figures given by the following concerns will serve as an example: The Union Stock Yards of West Fargo, North Dakota has its own well, 211 feet deep with a flow capacity of at least 2,500 gallons per minute and an annual estimated consumption of 116,538,000 gallons; The Fairmont Creamery Company, Moorhead, Minnesota has three wells of its own, 222 to 240 feet deep with a flow capacity of 200 gallons per minute each, their annual consumption is listed as 148,000,000 gallons of water; the Northern Packing Company, Grand Forks, North Dakota buy their water from the city and list a consumption of 22,500,000 gallons annually; the American Crystal Beet Sugar Company of East Grand Forks, Minnesota uses river water with an annual consumption of 400,000,000 gallons.

Even if industry is limited in the basin, dependence of such industry as has developed, upon the water supply of the basin, is clearly shown by the preceding few examples.

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